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ON SPONTANEOUS COMBUSTION.

(Continued from page 178.)

On Spontaneous Inflammations. By C. BARTHOLDI, *Professor of Natural Philosophy and Chemistry* *.

THE name of spontaneous inflammation is given to that manifested in a combustible body, without its being in immediate contact with a body in a state of inflammation.

Combustion of this kind may be occasioned by different causes, the principal of which are:

1st, Violent friction.

2d, Action of the sun.

3d, The disengagement of the caloric produced in bodies though not combustible, but brought near to combustible bodies, to which they may communicate such a degree of heat that they inflame by the contact of the air.

4th, The fermentation of animal and vegetable substances heaped up in a large mass, which are neither too dry nor too moist, as hay, dung, &c.

* Tilloch. v. 18, p. 346: from the *Annales de Chimie*, No. 144.

5th, the accumulation of wool, cotton, and other animal and vegetable substances, covered with an oily matter, and particularly a drying oil.

6th, The boiling of linseed oil for printers ink, of varnish, and in general of every fat matter.

7th, The torrefaction of different vegetable substances.

8th, Sulphurized and phosphorized hydrogen gas disengaged in several operations of nature, the last of which in particular inflames merely by the contact of the atmospheric air even at a low temperature, and which often presents itself at the surface of the earth like a small flame, known under the name of *will-with-the-wisp*, in places where animal substances in a state of putrefaction have been buried: if there are other combustibles at that time on the spot where the disengagement takes place, they may readily be kindled.

9th, Phosphuret of lime and of potash which may be formed in the preparation of charcoal, especially in that of turf and some sorts of wood which grow in marshy places. This charcoal, when wet, or by merely attracting the moisture of the atmosphere, forms phosphorated hydrogen, which by the contact of the atmospheric air inflames, and may set fire to the whole mass of charcoal.

10th, The phosphorus which is sometimes formed, though rarely, in the carbonization of different kinds of wood, without being combined either with lime or potash in the state of phosphuret. This charcoal does not inflame spontaneously at the common temperature of the air; but it may produce a detonation when struck with nitrate of potash, or some other nitrates or metallic oxides to which oxygen weakly adheres, and which are found in a state of thermoxide retaining a great deal of latent caloric.

1. *Friction.*

It is generally known that two bodies when rubbed against each other become heated. The intensity of the

heat produced depends on several circumstances, and varies chiefly in the ratio of the duration of the friction, and of the nature and surface of the rubbed bodies. If the friction takes place between combustible bodies, such as wood, the heat it excites may often be sufficient to inflame it; if the bodies are not combustible, such as stones, or little combustible, as metals, they do not inflame themselves; but they may communicate to other combustible bodies around them such a degree of heat that the latter will inflame by contact with the atmospheric air.

D. Palcani repeated the experiments long known for obtaining fire by the friction of two pieces of wood, giving to one of the rubbing pieces the form of a tablet, and to the other that of a spindle or cylinder: the result of some of these experiments will be sufficient to show, that, in the construction of machines and instruments, more attention ought to be paid to the choice of the wood destined to be exposed to mutual friction.

Cylinders.	Tablet.	Duration.	Effect.
Box wood	Box	5 min.	Sensible heat.
Ditto	Poplar	Ditto	Ditto
Ditto	Oak	Ditto	Ditto
Ditto	Mulberry	3	Considerable heat and smoke
Ditto	Laurel	Ditto	Ditto
Laurel	Poplar	2	Ditto
Ditto	Ivy	Ditto	Ditto
Ivy	Box	3	Ditto
Ditto	Walnut	Ditto	Ditto
Olive	Olive	Ditto	Ditto
Mulberry	Laurel	2	Consid. heat, smoke, and blackness
Ash	Oak	5	Sensible heat
Ditto	Fir	Ditto	Ditto
Pear-tree	Oak	Ditto	Ditto
Cherry	Elm	Ditto	Ditto
Plum	Apple-tree	Ditto	Ditto
Oak	Fir	Ditto	Ditto

Changing the experiment, and rubbing a cylinder of one of the kinds of wood between two tablets of the other, a cylinder of poplar for example between two tablets of mulberry wood, the increase of the rubbed surfaces which are in contact with the air produced a heat much more considerable, and almost the whole of the kinds of wood above enumerated took fire.

The effect of friction still varies according as the woods employed, especially if they are of the same kind, are rubbed in the direction of the fibres, or when the fibres cross each other. In the first case, the friction and heat are much more considerable than in the second.

In large machines where there is much friction, heating may be prevented by continually directing a current of cold water on the rubbing surfaces: in common machines, carriages, &c. it is diminished by covering the surfaces with an oily matter. There are many instances, during the great heats in summer, of carriages and other machines exposed to violent motion inflaming, because care has not been taken to grease them. Grease, by hardening on the rubbing surfaces, instead of lessening the friction increases it; and as this covering is highly combustible, it renders spontaneous inflammation more easy. In many cases, therefore, it is better to rub the machines with soap, talc, plumbago, or other substances, which without being oily are very unctuous to the touch.

2. *Action of the Sun.*

The strongest heat is produced, all sorts of combustibles are kindled, and the most refractory substances are fused by exposure to the sun's rays concentrated by means of lenses or concave mirrors. It may happen that other bodies are in such a condition as to produce without our will the effects of lenses and of burning mirrors: though these effects are rather physical than chemical, it is of

importance to make them known, in order to guard against the danger of them. We have instances of fires produced by glass decanters filled with water and exposed to the sun in an apartment. When the form of the vessel is nearly similar to that of a lenticular or spherical glass, the rays are refracted, and produce, by uniting in the focus, a heat capable of setting fire to combustible bodies placed in it.

3. *Heat excited in non-combustible bodies.*

It is well known that quicklime immersed in water, or merely moistened, produces a considerable degree of heat. It has even been employed with success for heating at a small expense apartments, hot-houses, hot-beds, &c. This property which quicklime has of disengaging a great deal of caloric by contact with the air, and that no less dangerous of dissolving and corroding animal substances immersed in it, require the greatest precautions where considerable depots of quicklime are formed. To preserve it, care must be taken to guard it from the contact of the air, and from moisture of every kind; and particularly to remove from its neighbourhood all combustible bodies, such as wood, hay, straw, &c., which might inflame spontaneously should the lime contract the least humidity. The *Journal de la Houte-Saône* gave an account last year of the burning of a barn, one of the partitions of which being wood had caught fire, because a heap of quicklime, intended for repairing the farm-houses, had been carelessly thrown against it.

A great number of similar phænomena take place in nature, where bodies, by changing their composition, or contracting new combinations, become so heated, or disengage so much caloric, that other combustible substances around them may be inflamed.

4, *Fermentation of Animal and Vegetable Substances.*

Most animal and vegetable substances, if heaped upon each other while they still retain their moisture, enter into fermentation; a change is effected in their composition, and they often become so much heated as to inflame. In this manner, haystacks, turf, flax, hemp, straw, and heaps of rags in paper manufactories, take fire.

The principal precautions ought to be employed in regard to hay: if cut in a rainy season, it is generally stacked before it is completely dry, and in this state it is the more disposed to ferment and become hot. As soon as a stack of hay is observed to be in a state of fermentation, care must be taken not to throw it down too speedily. The exterior strata ought to be slowly detached one after the other. When an opening is made in the middle of a heated mass of hay, it almost always happens that the fire suddenly bursts forth.

Nothing, however, is easier than to prevent such fatal accidents. When it is apprehended that hay about to be stacked is not completely dry, it will be sufficient to strew over each stratum a few handfuls of muriate of soda (common salt). The expense in this case ought to be a consideration of no importance; for the salt, by absorbing the moisture of the hay, not only prevents its fermentation, and the inflammation which thence results, but it adds also to the hay a savour which excites the appetite of the cattle, assists their digestion, and preserves them from a great many diseases.

During the great heats of summer it often happens that heaps of dung inflame spontaneously. Great care therefore must be taken to water dunghills from time to time, and to keep them at a certain distance from houses, both to prevent fires and for the sake of salubrity.

5. *The Accumulation of Animal and Vegetable Substances covered with Oil.*

If animal and vegetable substances heaped up in a large mass can be inflamed in consequence of the heat produced by their decomposition, this accident is more to be apprehended when they are covered with oily matters, and especially a drying oil.

Besides the accident which happened at the manufactory of Lagelbart, and of which my colleague Haussman has given an account, and the fire which took place in one of the finest manufactories at Sainte Marie aux-Mines, we have other instances of wool, stuff, and pieces of cloth which were not scoured taking fire in magazines when folded up, and even during the time of their conveyance from one place to another, when heaped upon each other. This is principally to be apprehended when linseed oil is employed in the manufacturing of cloth, or any other oil drying of itself, or rendered drying by oxide of lead.

In cloth manufactories, therefore, no oil but olive or rape oil ought to be employed for greasing wool.

It sometimes happens that in boiling flowers and herbs in oil, which is the case in several pharmaceutic operations, these herbs, after being taken out and dried, inflame spontaneously: care, therefore, must be taken, when they are thrown aside, not to heap them up near other combustible bodies.

We have several instances of ships having been burnt in port either by the spontaneous combustion of cordage heaped up and strongly covered with pitch, or of a mixture of boiling linseed oil and lamp black inclosed in a bag.

6. *The Boiling of Oily Matters.*

In the preparation of some kinds of varnish, such as printers' ink, where in general linseed oil boiled to a

certain consistence is employed, it often happens that the oil inflames, if the necessary precautions are not taken. The same effect is produced in melting butter, tallow, or any other greasy substance, if it be too much heated; so that in these operations every other combustible body should be kept at a distance, and a covering should be in readiness to place over the vessel as soon as the matter has caught fire: care also ought to be taken not to pour in water, which, instead of extinguishing the fire, would give more expansion to its activity.

7. *Torrefaction.*

There are many vegetable substances which by torrefaction acquire an increase of their property to inflame spontaneously if inclosed in bags of cloth, which leave them in contact with the surrounding atmosphere. Of this kind are sawdust, burnt coffee, the farina of gramineous and the fruits of leguminous plants, such as beans, lentils, pease, &c.

There are several instances of fires breaking out in stables by a bag of torrefied bran applied to the neck of a diseased animal, and which inflamed spontaneously. The people in the country persist in employing this remedy, for which others more efficacious and less dangerous might be substituted. At any rate, they ought to take care not to inclose the bran in cloth either too hot or too much torrefied.

Brewers, after causing the barley and other grain which they use for beer to germinate, dry it in a kiln or stove, except that destined for pale beer; and they generally dry it in a greater or less degree, to give to the beer a colour more or less dark. If the grain when taken from the kiln is put warm into sacks, it sometimes happens that they inflame, and occasion fires in brew-houses.

8. *Sulphurized and Phosphorized Hydrogen Gas.*

Subterranean fires and volcanoes are generally ascribed to the decomposition of pyrites and metallic sulphurets buried in the bosom of the earth. These pyritous masses are decomposed by the contact and concurrence of water and air, and the decomposition is always accompanied with a great expansion of caloric, and a disengagement of a highly inflammable gas called sulphurized hydrogen gas. This gas inflames at an elevated temperature, and may communicate inflammation to the sulphur of pyrites, to coals, and other bituminous matters with which they are in general accompanied.

Similar inflammations are observed sometimes in the neighbourhood of coal mines. In working coal mines, veins and insulated pieces of pyrites are often found: as pyrites always communicates a bad quality to coal, the miners generally lay it aside and take it out of the pit. If these heaps of pyrites, intermixed with coal, are then exposed to the alternate action of the sun and rain, they become heated, and inflame. Great care must therefore be taken that such heaps of pyrites be removed from all combustible bodies to which they would necessarily communicate inflammation. There are many operations in nature in which sulphurized hydrogen gas is produced; but it often forms other combinations, according as it is dissolved in water, or is disengaged at a temperature too low to be able to inflame.

When phosphorus is boiled in a solution of potash or of lime, there is disengaged phosphorized hydrogen gas, which being much more combustible than sulphurized hydrogen gas, inflames at a low temperature as soon as it comes into contact with atmospheric air. This gas, which in chemical experiments exhibits the beautiful spectacle of a fountain of fire over water, is produced naturally by

the putrefaction of animal substances which have been buried. The flames often seen to issue from the earth, and which are known under the name of will-with-the-wisp, arise only from phosphorized hydrogen gas: as these fires generally appear in the open fields in places where they are not in contact with dry combustible matters, they rarely produce disagreeable accidents; but it is disengaged also in forests, and it may happen in very warm summers, when the grass and bushes are entirely dry, that the gas in combustion will meet with these combustible matters, set fire to them, and in this manner burn the whole forest. We ought not therefore, on too slight grounds, or without sufficient reason, to ascribe to malevolence or to incendiaries those fatal events which sometimes are the result of causes purely natural.

9. *Sulphuret and Phosphuret of Lime and Potash formed during the Combustion of several Vegetables.*

When gypsum (sulphate of lime) or any other sulphate, either earthy or alkaline, is strongly heated with charcoal of wood, or in general with any combustible matter which by heat is reduced to charcoal, sulphur is formed. These salts produce sulphureous waters, if animal or vegetable substances are suffered to remain in water in which they are dissolved, so that very often nothing is necessary but a little sulphate of lime to communicate to stagnant water the odour and taste of sulphur.

Pyrophorus is obtained by calcining common alum or sulphate of potash with sugar, farina, or any matter which becomes reduced to charcoal.

The inflammation of pyrophorus, which takes fire merely by the contact of damp air, arises only from the sulphuret of potash, which by attracting the humidity of the air becomes heated to such a degree as to set fire to

the carbonaceous matter around it, and which being in a state of great tenuity is the more disposed to burn.

But as many of our common combustible matters contain sulphuric salts, it may happen that in their combustion there is sometimes accidentally formed some pyrophoric matter, which remains in the residuum of the combustion; especially if the combustible matter is not entirely consumed, and if a part of it only is reduced to charcoal; which sometimes happens in fire-places where the combustibles are not burnt in grates, and where the ashes are not separated from the charcoal. There have been instances of houses being set on fire by ashes intermixed with charcoal taken too soon from the hearth and deposited in places where they were surrounded by combustibles, which they set fire to by spontaneous inflammation. Happily these causes of fires rarely occur; for pyrophorus does not long retain its property of inflaming, and it is often decomposed soon after it has been formed, without being able to produce that disagreeable event. Care, however, ought always to be taken not to put ashes newly burnt, and which are still mixed with charcoal, in places where they may have a communication with combustibles.

The formation of a pyrophoric matter is remarked chiefly in the preparation of common soda, which is obtained by the incineration of several marine plants containing a great deal of sulphate of soda, and which in burning furnish always a greater or less quantity of sulphur according to the manner in which the operation is directed.

The formation of the phosphuret of lime has great analogy with that of the sulphuret of lime. Though the phosphoric acid is not found so often in vegetables as the sulphuric acid, it however exists in them in much larger quantity than has hitherto been supposed; it is found chiefly in the greater part of plants which grow in marshy

places, in turf, and in several kinds of white wood. By reducing these kinds of wood to charcoal there is sometimes formed a small quantity of phosphorus, which may remain combined with the same bases which retained the phosphoric acid before the combustion: phosphorus, by contracting other combinations, may be no longer susceptible of producing any accident; but it may happen also, by the concurrence of various circumstances, that charcoal impregnated with any phosphuret, when exposed to the action of warm and moist air, will disengage phosphorated hydrogen gas, which by the contact of the atmospheric air may kindle, and communicate inflammation to the mass of charcoal.

Two instances of this kind of spontaneous combustion took place in the powder manufactory of Essone in the years 8 and 10. The first time the fire broke out in the box for sifting the charcoal, and the second time the charcoal repository took fire, without room being left for suspecting that it could arise from any thing but spontaneous inflammation. The different reports on these two events were inserted in the public journals, but the explanations given were not sufficiently satisfactory. It appears very probable that they were occasioned by some phosphorus contained in the charcoal; and this explanation is the more founded in reason, as the alder wood used at Essone as well as in most of the powder manufactories, and which on many accounts deserves the preference over other kinds of wood for the making of gunpowder, contains phosphoric acid; at least that which grows in our neighbourhood does.

Charred turf begins to be used in some manufactories, and for different operations; but as it is much disposed to spontaneous inflammation, the use of it ought to be abandoned, or great care should be employed in preserving it. Magazines of this substance, both at Paris and

other places, which were uncovered, have been inflamed by the combined action of the heat and rain.

10. *The Phosphorus contained sometimes in Charcoal.*

It may happen also that the small quantity of phosphorus, which is sometimes formed in the carbonization of different kinds of wood, without uniting to lime or to potash, remains combined with the charcoal, which in this case does not disengage phosphorated hydrogen gas, and does not easily inflame by the mere action of water or moist air, but which may produce a violent detonation when struck with saltpetre (nitrate of potash.) It is very probable that the three successive explosions which took place in the powder-mill of Vonges were in part owing to a similar cause.

Charcoal in general has a great influence on the different products of nature and the arts. It is often observed in forges and founderies, especially those of iron, that the products vary according to the nature of the charcoal employed. The bad quality found sometimes in iron of being cold short is generally ascribed to phosphoric acid contained in the ore; but as the ore by the same processes furnishes in the same foundery one kind of iron better than another, the difference appears often to arise in part from the charcoal.

No. 34.

Addition to a Memoir on the Method of giving to Cotton and Linen thread the Adrianople Red, and other fixed Colours, and on Spontaneous Inflammations. By J. M. Haussman *.

To give to cotton and linen thread all kinds of durable colours, nothing is necessary but to fix on these

* Tilloch, v. 18, p. 340. From the *Annales de Chimie*, No. 144.

threads, in any manner whatever, more or less alumine, after having applied to them a slight stratum of oil. The complete success of the result, however, depends on certain modifications to be observed in the processes.

The numerous trials which I made in dyeing had so much familiarised me with experiments on a small scale, that I at last never failed. It was only after I published my memoir on maddering inserted in the *Annales de Chimie**, that I experienced any difficulties in the application of oil when operating on a larger scale. Linseed oil, which had always given me a milky mixture in limited proportions with alkaline solution, then speedily separated when I wished to make a larger provision, and under these circumstances the impregnation of the skains became impossible. The case was the same with all the fat oils: fish oil, however, will remain in mixture for a considerable time; but its odour is too disagreeable.

To remedy the inconvenience of the separation of oil in the alkaline solution of alumine, I had recourse to drying oils; that is to say, oil boiled with metallic oxides. Linseed oil boiled with minium, ceruse, or litharge, by means of water to prevent combustion, dissolves a considerable portion of the oxide of lead, and will keep mixed with the alkaline solution of alumine, under the milky form, the whole time necessary for the impregnation of the skains. By employing this mixture in proper proportions, and in the manner I have indicated in my memoir, following strictly in other respects the process such as I have described it, one cannot fail to obtain beautiful and lasting colours. However, notwithstanding the simplicity of this process, I cannot recommend the use of it, because it exposed me to the danger of a conflagration in the following manner:

* See Emporium, preceding numbers.

With a view to discover whether red cotton, which had not the requisite fixity, could acquire it by impregnating it with an alkaline solution of alumine, with excess of boiled linseed oil, and drying it, and then boiling it a very long time in bran water, I mixed the alkaline solution of alumine in the proportions of an eighth, a twelfth, and a sixteenth part of boiled linseed oil. I then immersed in this mixture some dozens of skains of dyed cotton, which, after being dried in the open air for a whole day the preceding summer, were placed under the window of my cabinet, on a straw-bottomed chair. Being that day indisposed, I went to bed at seven in the evening, without any uneasiness in regard to my cotton. My children, about an hour after, went into my cabinet to look for some sheets of paper, and observed in the cotton neither heat nor any smell of combustion. All the workmen of the manufactory were in a state of profound sleep, when one of the watchmen of the bleachfield, seeing my cabinet all illuminated, called out "Fire!" and awaked us between twelve and one o'clock in the morning. My sons, knowing that I was not able to get out of bed, and unwilling to lose time in searching for the key, burst open the door of the cabinet, which is an uninhabited and detached building. They entered, notwithstanding the thick smoke and insupportable odour of the oily combustion, and found the cotton and chair so much on fire, that the flame, which rose to the ceiling, had already broken the glass and burnt the frame of the window. They immediately concluded, that this fire could arise only from the spontaneous inflammation of the cotton impregnated and covered with boiled oil, since no person had entered the cabinet either with a lighted pipe, or with any other matters in a state of combustion. Observing that several persons in the manufactory refused to assent to this explanation, I again impregnated some dozens of skains of old

cotton, which had been badly dyed, in the same manner as the burnt cotton. I then dried them in the open air; and seeing that the weather threatened rain, I exposed them on a rope, extended above the court, desiring one of the night watchmen to look at the cotten every quarter of an hour, and to throw it into a bucket of water as soon as he should see it begin to become heated. But as the man could not conceive the possibility of the spontaneous inflammation of cotton, as he himself acknowledged, he went his rounds without so much as looking towards the court. At length, however, he came back to rest himself, and, by the great light he perceived, was convinced of what I had foretold would be the consequence of neglect. Finding that the cotton and rope were both burnt, he took the bucket of water to extinguish the supporters, which were already both on fire.

About fifteen years ago, with a view of preventing similar dangers, I made experiments at Colmar on spontaneous inflammations. I mentioned the probability of fires being occasioned by warm bodies, or bodies tending to be heated, when deposited inconsiderately in places to which fire may be communicated. The bodies of this kind, which I mentioned to those present, who were not sufficiently acquainted with the phænomena of spontaneous inflammations, are roasted coffee, cacao, fermenting plants, ointments made with metallic oxides, inclosed quite hot in wooden barrels, bales of raw cotton, as well as linen or flax heaped on each other at a warm temperature, and even linen which has been ironed and put warm into drawers; in a word, all bodies covered with oil, such as silk and skains of cotton. I showed them besides, that in all cases where the oxygen of the atmosphere is rapidly attracted and absorbed by any cause whatever, the caloric, which served as a base to the oxygen and gave it the qualities of gas, or elastic proper-

ties, is disengaged in such abundance, that if the absorbing bodies are susceptible of taking fire, or if combustible bodies are in the neighbourhood, a spontaneous inflammation will take place.

To prove to the persons present, to whom chemical experiments were not familiar, the theory of these inflammations, I made the following experiments :—1st, The incandescence of a mixture of iron filings and sulphur kneaded in water.—2d, The inflammation of boiled linseed oil by means of highly-concentrated nitric acid.—3d, The inflammation of phosphorus in atmospheric air, as well as in pure oxygen gas, placed for that purpose in a porcelain capsule over boiling water, in order to separate the moleculæ by fusion without having recourse to friction.—4th, The inflammation of phosphorated hydrogen gas by the contact of the atmosphere—an imitation of will-with-the-wisp.—5th, The combustion of pyrophorus thrown into the atmosphere, and in pure oxygen gas.—6th, The reduction into a charry igneous mass, produced by the action of the atmospheric air of torrefied bran put quite hot into a bag, the texture of which was not too close.

I was well aware, that essential or volatile oils become resinous, and that drying oils boiled with metallic oxides become thick and hard in consequence of their combination with oxygen. It was also for this reason that my skains, covered with a mixture of boiled linseed oil, were exposed during the whole day to the air, extended and insulated on poles ; but I then supposed them to be saturated with oxygen, and consequently incapable of producing the least accident. I was so secure in this point that I caused a great deal of impregnated cotton to be dried at several times in warm apartments ; they were not deranged but at the moment when they were washed in order to be dyed. It may however be possible that the

proportion of a thirty-sixth part of boiled linseed oil, mixed with an alkaline solution of alumine, may be insufficient to excite spontaneous inflammation in skains of cotton heaped up after they have been dried. Those, therefore, who are induced, on account of the simplicity of the process, to employ a mixture of boiled linseed oil with an alkaline solution of alumine, must take the precaution to leave the skains extended and insulated on poles, until they are to be washed, previous to the operation of dyeing, which, together with the brightening, completely removes the excess of oil, and leaves only the portion saturated with oxygen; so that no fears need afterwards be entertained.

Since the publication of my memoir, I have convinced myself that the simplest brightening of Adrianople red, by which the liveliest and most durable shades are obtained, consists merely in very long ebullition in bran water in a boiler furnished with a cover, having in the middle a pipe to suffer the vapours to escape, and prevent the bursting of the vessel; care only must be taken to renew the water as often as it becomes red; that is to say, two or three times at the commencement of the ebullition. Without this precaution the skains would continually resume the fawn-coloured parts which the bran water removes, and would never acquire a bright colour.

One may avoid all danger without lessening much the simplicity of my process, whether the skains be heaped up or not: nothing is necessary but to apply at two different times a stratum of olive oil, very much divided, after they have been well lixiviated, washed, and dried. For this purpose, a ley is formed of carbonate of potash or soda, which indicates one degree, or a degree and a half, of the areometer for saltpetre. Some drops of olive oil are then dropped into it, to try whether the result will be a milky mixture, or whether the oil will ascend in its

natural state to float over the ley; for, as the alkaline carbonate may contain more or less heterogeneous parts, in that case the ley must be weakened or strengthened by a new portion of alkali, until it absolutely assume a milky appearance by the mixture of oil. When the ley is properly proportioned, thirty-two parts of it must be mixed at first gradually and then more rapidly, continually stirring it, with one part of olive oil. This milky mixture will keep a long time; and if it be observed that the oil attempts to float under the form of cream, the mixture must be again stirred. The impregnation of the skains should be intrusted to workmen most experienced in this operation, because an exact distribution of the oily parts has a great influence in regard to the equality of the shades. Each workman ought to put as much of the milky mixture into any vessel as will admit of a certain number of skains to be squeezed and twisted in it with facility. This labour must be continued, always taking the same number of skains and the same quantity of milky mixture. The part which has been expressed, each time, must be poured into a vessel apart; and the quantity of oil which the skains appear to have absorbed must be restored, if the little value of this residuum, in consequence of its containing but a small quantity of oil, does not make it be rejected. The impregnation may be effected in the whole mass of the milky mixture; but in this case it will be necessary to continue to replace the quantity of oil which the skains may have absorbed, as soon as a diminution is observed in the intensity of the milky appearance. Expertness in this process may be easily acquired by practice. After the whole skains have been dried together, they must be impregnated a second time as before without being previously washed; and when they have been dried they may be impregnated, as I have mentioned in my memoir, either once, two or three times, in the

alkaline solution of alumine, pure and without any mixture: by immersing the skains, shades more or less dark will then be obtained according to the number of impregnations.

To obtain, however, bright and at the same time uniform shades, it will be better to employ three impregnations, properly weakening the alkaline solution. One may then impregnate three times successively in this concentrated or weakened solution without previous washing: by these means the manipulations, which are often tedious and troublesome, may be shortened; but in this case it will be necessary to examine the solution from time to time, to see whether what the impregnated and dried skains discharge in it do not render it too strong.

In re-dyeing shades of red, it will be necessary to ascertain first whether they have been brightened by means of boiling bran water, or by soap and alkalies. In the first case they will become darker, by still attracting colouring particles of the madder; in the second they are weakened, and lose the excess of alumine, without which repeated dyeing can produce no effect. The removal of this excess of alumine may be prevented by substituting for soap and alkalies, to produce crimson shades, a portion of the alkaline solution of alumine, which must be added to the bran water towards the end of the brightening. Real Adrianople reds become much darker by re-dyeing them, and turn brown by the test of ebullition in water alkalized by ashes: these reds change only very little before they are re-dyed. In general, reds become brown more or less disadvantageously according to the time they have been boiled in brightening them. As the real Adrianople reds have a strong smell, it is probable that the Turks employ fish oil, which they add directly to the alkaline solution of alumine, or mix with a very weak ley of alkaline carbonate.

The processes for dyeing Adrianople red can be infinitely varied; for in whatever manner and by whatever solvents, whether acids or alkalies, the alumine may have been fixed on the skains, when a light stratum of oil has been applied, reds more or less bright will be obtained, according to the precaution employed in maddering and brightening.

It appears to me more difficult to explain the reason why oils combine so easily with caustic alkalies to form soaps, and do not admit of being mixed with concentrated leys of alkaline carbonates, while they form a kind of artificial milk with these leys when very much diluted, because one might suspect a tendency to combination in such milky mixtures. A mere suspension of the integrant oily moleculæ, which would take place rather in the diluted ley than in the same ley more concentrated, is equally difficult to be explained.

It remains that I should rectify an injury done to the process for dyeing real Adrianople red in other manufactories. What was shown to me was only of the most inferior quality. I have seen some since equal to the finest and most durable that can be produced. So that I am inclined to think that the merchandize of the Turks, like that of all other nations, is suited to the price which the purchaser wishes to give.

I must observe also, that among my burnt cotton there was some both times which had been impregnated with a weak ley of carbonate of soda and boiled linseed oil in the proportion of an eighth, a twelfth, and a sixteenth. It therefore remains to ascertain whether this cotton will sooner catch fire than that impregnated with a mixture of the alkaline solution of alumine and boiled linseed oil in the same proportions. As the latter mixture is susceptible of attracting a little of the moisture of the air, I am inclined to think that cotton treated with the first will inflame

sooner. The trials which I continue to make in regard to the use of gall nuts in dyeing Adrianople red, induce me to believe that it is by the formation of a gallate of alumine that alumine is fixed upon cotton, that the gallic acid may be afterwards separated by an alkaline carbonate before the process of dyeing is begun. When I have acquired certain information on this subject, I shall not fail to publish the result.

No. 35.

Agenda, or a Collection of Observations and Researches, the Results of which may serve as the foundation for a Theory of the Earth. By M. DE SAUSSURE.

(Continued from page 208.)

CHAPTER XV.

Observations to be made on primitive mountains.

1. WHETHER there be any exception to the generally received opinion, that, in primitive mountains, no vestiges are discovered of organised bodies.

2. Whether it be true that in these mountains no indications are found of bitumen or marine salt.

3. To endeavour to determine the respective ages of the different kinds of primitive mountains; both compound, such as granite, porphyry, gneiss; and simple, as slate, serpentine, and primitive calcareous.

4. Whether, in particular, it be certain that granite is the most ancient stone of all those which form the outer crust of our globe, so that it is never found placed above (*superpose*) any other kind of stone.

5. Whether the large mountains composed of granite in one mass, even the best characterised, do not give certain indications of stratification or divisions by strata, though less regular than those of schistous mountains.

6. Whether in the bases of granite mountains the manifestation of strata be not hurt by the number of fissures, or spontaneous and irregular divisions.

7. Whether, even in the separate blocks of granite, an attentive eye does not discover some veins of mica, which affect the same direction, and such veins as induce the workmen, who wish to make mill-stones or other works more extensive in one direction than another, to prefer attacking the stone in a determined direction.

8. Whether the indications of the stratification are not observed in the interior part of granite mountains, as well as near their surface.

9. Whether among the granites in a mass, and those decidedly veined, there are not found such intermediary shades that it is difficult to mark the line of separation.

10. To determine the distinguishing characters of granites of modern formation.

11. To ascertain the truth of the assertion of the Pliny of France, that in proportion as people dig into a mountain, the summit and sides of which consist of granite, the granites, instead of being found more solid and more beautiful the farther they advance, change, on the contrary, below a certain depth, lose themselves, and at last vanish by gradually assuming the coarse (*brute*) nature of the live quartzy rock *.

12. Whether it be true that each primitive mountain is generally composed of one single stone, and of the same nature.

* Mineraux, p. 105.

13. To examine whether there be found on the primitive mountains, at great heights, the scattered wrecks of secondary mountains. For my part, I never found any.

14. Whether primitive calcareous stone be found always with a granulated fracture, or the form of a saline marble, and never under a compact form.

15. Ought the porphyric schist of Werner, or the *porphyre schisteux a pate* of primitive petro-silex, to be considered as primitive or secondary? The same question in regard to the *mandelstein* or amygdaloid.

16. Is it fully ascertained, as I thought I observed in the Alps, and M. de Fichtel in the Carpathian mountains, that there exists pudding-stone or free-stone, if not primitive, at least of a formation anterior to that of all the other secondary stones?

17. Were the granites in a mass first deposited, because they were less soluble? and did they crystallise after the quantity or dissolving force of the waters began to diminish? and was it for a contrary reason that the gneiss, mica and magnesian stones crystallised later?

CHAP. XVI.

Observations to be made on Transitions.

1. To observe the intermediary genera and species of fossils, between one genus or one species of fossil, and the genera and species which have the greatest resemblance to them.

2. To observe, above all, the transitions through which nature has passed, when, having produced one genus or one order of mountains, she began to produce a different genus or order; for there is no change of order which has not been the effect of a revolution; and it is in the transitions that traces of these revolutions are to be found.

3. Thus we often see strata of free-stone or pudding-stone interposed between the primitive and secondary mountains; *breches* are seen to form the most elevated stratum, and consequently the newest of some calcareous mountains. We must study then the nature, dimensions and position of these remarkable strata.

4. Having found these transitions, or any others, in some mountains, if they are not then found in other mountains, you must examine whether their absence does not arise from their having been destroyed; vestiges of them are to be sought for; and if it appears that they never existed, you must endeavour to discover, in the nature and position of the mountains, what may have been the cause of their absence *.

CHAP. XVII.

Observations to be made on the Remains and Vestiges of organized Bodies found in the Earth, in Mountains, and at their Surface.

1. Their nature, bulk, and quantity; the extent, depth, and other dimensions of the strata where they are found†.

2. Their preservation. Whether entire or broken, decomposed or not; shells with their pearly covering (*nacre*); their colour; remains or traces of their fish, or their skin if there be any. To deduce, if possible, from these data, some idea of the time that has elapsed since these organised beings were deposited in the bosom or at the surface of the earth.

* The best method of observing mountains, in order to acquire a thorough knowledge of them, is, not to confine oneself merely to follow the valleys, but to intersect also, as much as possible, the principal chains and the branches detached from them in the direction of their breadth. Til.

† 1. A. If formed of trees, to mark down the direction of the strata; and whether they are placed horizontally, or inclined either towards the summit or the roots. Til.

3. The nature of the objects by which they are accompanied; such as sand, gravel, flints: whether angular or round; whether there are found in their neighbourhood other vestiges of organised bodies *.

4. Their nature. Whether they are lying in their natural position, or reversed, and turned upside down, so as to afford reason to conclude that they died on the spots which they now occupy; or whether they have been transported thither by some violent and irregular movement: whether, for example, the shells have the same attitude as in the bosom of the sea, the univalves on their mouth, and the bivalves on the valve that is least convex.

5. Whether they are in families, as in stagnant waters; or, on the contrary, thrown together in an irregular manner.

6. Whether all these circumstances are the same throughout the whole extent of the same bank; in the contiguous banks of the same lands, and the same mountains, and in those of the neighbourhood.

7. To ascertain whether fossil shells are found in the most ancient mountains, and not in those of a more recent formation; and thus to class, if possible, the relative ages and epochs of the apparition of the different species.

8. To compare exactly the bones, shells, and fossil plants with the living plants analogous to them; and thus to ascertain the truth of the assertion of Michaelis, that the fossil bones of quadrupeds (such as the elephant, rhinoceros, oxen, and stags,) have not an exact resemblance to those which are found at present alive.

9. If they are really different, to determine whether these differences are not varieties, or whether they characterise species.

* To pay particular attention to those of such organised bodies as may be found in the real veins. Til.

10. Whether, on the other hand, their identity is confirmed with those of analogous living ones; viz. to ascertain whether these analogous living ones are found at present, or have been found within the memory of man, in those countries which contain remains of them; and if the answer is negative, to discover the situation and distance of the nearest country where they are found.

11. If no analogous ones exist alive at present but in climates where the temperature is very different, to ascertain whether there are any indications of their having formerly existed, and of their having been conveyed to those countries where remains of them are still found; or whether, on the contrary, these remains seem to have been transported thither by currents, tides, or any other great movement of the waters.

12. In the like manner, whether there are found in the cold countries vestiges of the productions of warm countries; or reciprocally, whether in warm countries there are found vestiges of the productions of cold countries.

13. Whether fossil wood, or other vestiges of organised bodies, are situated in such a manner as to indicate that there were in the ancient ocean islands abounding with animals and vegetables.

14. To study with care the immense accumulations of bones deposited in heaps (*nids*), or strata, in the isles of Cherso, Osero, and elsewhere.

15. To examine the nature of the caverns which contain them; such as *Baumannshœle*, and others *.

16. Whether it appears that these caverns were the voluntary retreats of those animals who died there a natural death, or whether their bodies were conveyed thither by the waters †.

* In the Harz, and those of Gailenreuth in Franconia. Til.

† Or, whether these bones are found, not only in caverns, but also in the strata from which the caverns have been formed. Til.

No. 35.

Description of a Portable Bridge, invented by Mr. James Elmes, *Architect, of College-Hill, Queen-Street, Cheapside, London* *.

(With a Plate.)

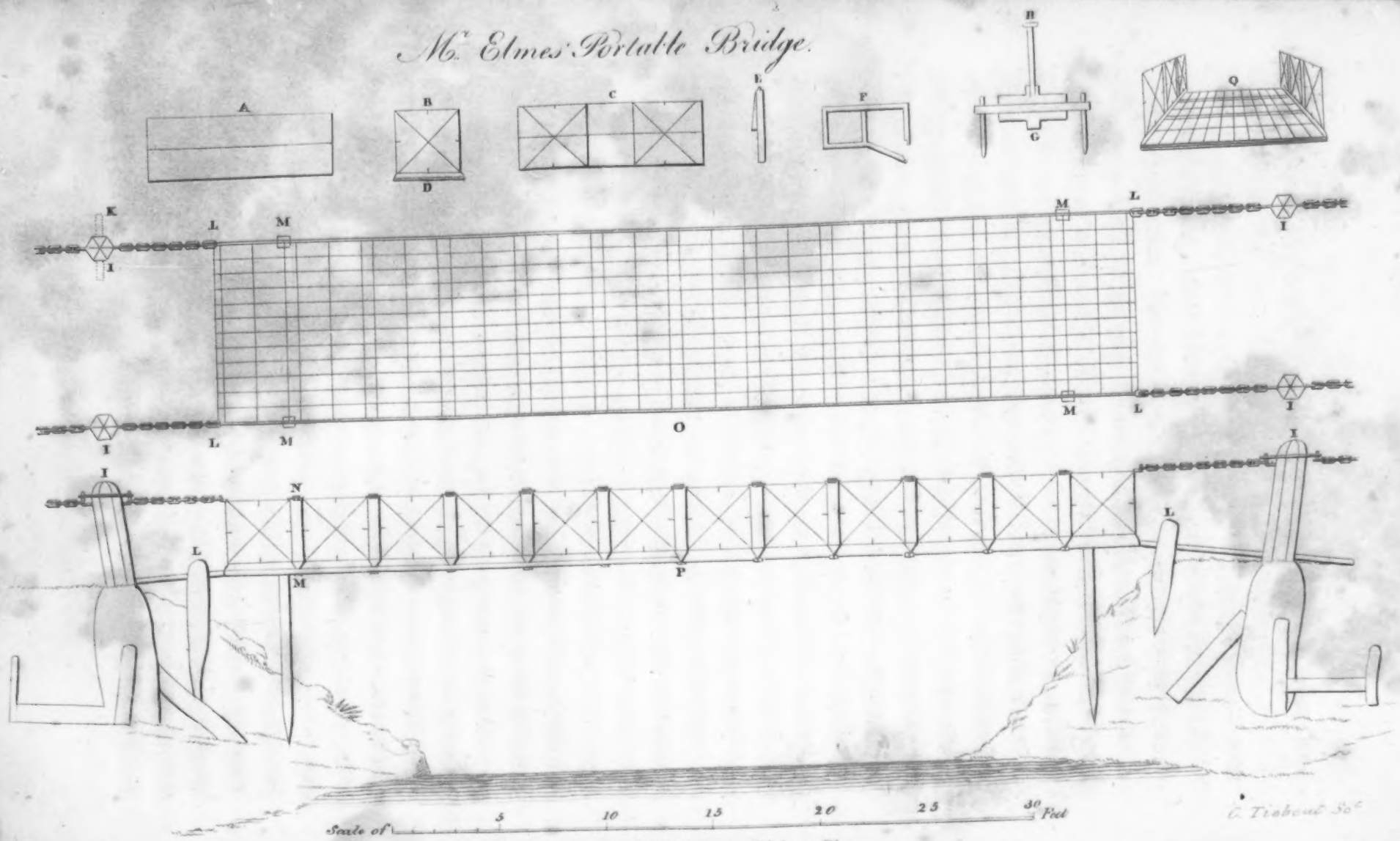
BRIDGES upon this construction may be rendered either permanent or otherwise. The only difference will be, that for the former the parts may be strongly bolted and fastened together, instead of being joined by contrivances which admit of the parts being separated, for the convenience of removal, as in the drawing now sent. (See plate 7.)

The component parts shall be first described, and afterwards the manner of applying them. A is a strong iron frame that forms the bottom. B is a square frame of the same metal, fastened by hinges, to the ends of A, for the purpose of falling down flat upon the bottom for conveniency of packing, as shown by the figure C. A skirting of iron plate marked D, is also strongly fixed to the bottom, as in the elevation of the whole P, and in the figure B. Two spring catches are attached to this skirting to keep the sides steady when erected. One of these catches E on a larger scale is shown in the drawing. The remaining detached parts are marked F and G. F is a square iron link separated in the middle, and each part opening by a spring. G is a kind of staple opening and closing by a double worm described round its superficies working in an interior screw, contained in a box, opening and closing very considerably by a single revolution of the box round the screw, by the means of a small handspike H.

As many of each of the above described parts as are necessary, according to the width of the river or valley

* Tilloch, vol. 33, p. 10. Communicated by the inventor.

Mr. Elmes' Portable Bridge.



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intended to be passed, with a sufficient quantity of planking posts, chains, &c., according to the existing circumstances of the case, are the whole of its component parts.

A bridge on this principle for a river, &c., of a considerable width is very portable; for several of the square frames may be packed upon each other in carriages or waggons of the dimensions of eight feet three inches long, three feet four inches wide, and as many feet high as it may be wished to pack a number of frames; two of them rising one foot. The links and staples can be packed in cases, each sort separate.

The method to be used in passing a river with this bridge shall now be described. (A valley is passed in the same manner; but there being no water to pass, the bridge will be easier supported from the under side.) First, two sufficient holes are to be dug on one side the river, at the distance apart of the width of the bridge, which in this plan is nine feet, and the posts I, are first to be prepared with prongs, &c., as in the dotted figure K: next the four smaller ones L, properly secured and well rammed. Then taking any one of the pieces C. fix it on the posts I and L as drawn, and support it on two well driven piles, if the shore will permit: and hooking on the next piece with one of the links F through the eyes at the bottom of the piece, and one of the staples G, fixed into the holes of the upright piece or parapet, it will there hang. Several more are to be hanged on the same way, leaving under them, where necessary, barges or other craft, moored with supporters under them *pro tempore*. When completed to the opposite shore, the same process of fixing the posts. &c., is to be repeated, and when fastened to these posts, the under supports may be taken away, and the whole left suspending by itself. Nothing now remains but for the superintendent of the work to screw the staples, by the handspike H, till the bridge ri-

ses by a small curvature by opening the interstices N at the top. It is not required to rise more than a small degree above level, only just enough to stiffen the whole, and cause it to lie like a stiff plank, and rather to occasion a thrust outwards than otherwise, which when the weight has brought down may be again raised by the same operation. The planks are now to be laid on to meet at the intervals as in the ichnographic plan O, of which P is the elevation complete. Q is a perspective view of three joints looking along the bridge with the planks, &c., drawn faintly.

No. 36.

A Treatise on the Cultivation of the Vine, and the Method of making Wines. By C. CHAPTAL.

(Continued from page 193.)

III. Of the Means requisite to dispose the Wine for Fermentation.

AS ripe grapes rot on the twigs, the faculty which the sweet and saccharine juice of the fruit possesses of being converted into a spiritous liquor may be considered as the pure effect of art, and it is by the fermentation of this juice expressed that this change is produced. The method of disposing grapes to fermentation varies in different countries; but as the differences occasioned in so essential an operation rest on certain principles, I have thought it proper to make them known.

We are informed by Pliny (*De brio vino apud Græcos clarissimo*), that the grapes were collected a little before their maturity; that they were dried by being exposed to

the ardent sun for three days, turning them three times every day, and that on the fourth they were expressed.

In Spain, particularly in the environs of St. Lucar, the grapes are left exposed for two days to the full ardour of the sun.

In Lorraine, part of Italy, Calabria, and the island of Cyprus, the grapes are dried before they are expressed. It is in particular when white sweet wines are to be made that the grapes are dried, to thicken the juice, and thereby to moderate the fermentation.

It appears that the ancients were acquainted not only with the art of drying the grapes in the sun, but even that they were not ignorant of the process employed to boil and concentrate the must; on which account they distinguished wines into three kinds, *passum*, *defrutum*, and *sapa*. The first was made from grapes dried in the sun; the second was obtained by reducing the must one-half by the means of heat; and the third, from must so concentrated that there remained no more of it than a third or a fourth. For very interesting details respecting these operations the reader may consult Pliny and Dioscorides. These methods are still used at present, and we shall show, when we come to speak of fermentation, that it may be directed and managed in an advantageous manner by inspissating a portion of must, and afterwards mixing it with the remainder of the mass; we shall show also that this is an infallible method for giving to all wines a degree of strength to which the greater part of them cannot otherwise attain.

Agriculturists were long divided in regard to the question, whether it is most advantageous to free the grapes from the stalks or not? Each of these methods has its partisans, and writers of merit may be quoted who have supported both. In my opinion, in this as well as in other cases, both parties have been too exclusive, and by bring-

ing back the question to its real point of view it will be easy for us to terminate the difference.

It is certain that the stalks are harsh and austere, and it cannot be denied, that wines produced from grapes not freed from the stalks do participate in that quality: but these are weak and almost insipid wines, such as the greater part of those made in moist countries, where the slightly harsh taste of the stalks heightens the natural insipidity of that beverage. Thus, in the Orléanois, agriculturists, after freeing the grapes from the stalks, have been obliged to abandon this method, because they observed that the grapes freed from the stalks furnished wines more inclined to become oily. It results also, from the experiments of Gentel, that fermentation proceeds with more force and regularity in must mixed with the stalks than in that which has been freed from them; so that in this point of view the stalks may be considered as an advantageous ferment in all cases where it is to be apprehended that the fermentation may be too slow or retarded.

In the environs of Bourdeaux the red grapes are carefully freed from the stalks when it is proposed to obtain good wine. But this operation is still modified according to the degree of the maturity of the grapes. It is much employed when the grapes have little ripeness, or when frost has taken place before their being collected; but when the grapes are very ripe, it is performed with less care. Labadie observes, in the information with which he has supplied me, that the stalks must be left to facilitate the fermentation.

White grapes are never freed from the stalks; and experience proves, that grapes separated from the stalks give wines less spiritous, and more susceptible of becoming oily.

The stalks, no doubt, add neither to the saccharine principle nor to the aroma; and in this double point of view, they cannot contribute by their principles either to the spiritous quality of the wine or to its flavour, but their slight austerity may correct, with advantage, the weakness of some wines; and besides, by facilitating the fermentation, they concur to effect a more complete decomposition of the must, and to produce all the alcohol it is susceptible of yielding.

Without wandering from the subject in question, we may consider wines also under two points of view, according to the uses to which they are applied. They are all employed either as a beverage or for distillation. In the former, qualities are required which would be useless in the second. Taste, which forms almost the whole merit of the one, adds nothing to the qualities of the other. Thus, when wine is destined to be distilled, it is necessary to pay attention only to the means of developing a great deal of alcohol: it is of little importance whether the liquor be tart or not; in this case, to free the grapes from the stalks would be lost labour. But if wine is prepared for a beverage, it is then necessary to give it an agreeable taste and a delicate flavour, and for this purpose, care must be taken to avoid every thing that may alter these valuable qualities. On this account, therefore, it is necessary to withdraw the stalks from the fermentation, to pick the grapes, and to clean them with care.

It is, probably, in consequence of a knowledge of these effects, which experience every day places before the eyes of the agriculturist, rather than from caprice or habit, that in certain countries the grapes are freed from the stalks, and that this process is omitted in others. To attempt to reduce the whole to one general method would be showing ignorance of the effects produced by the stalks in fermentation, and of the difference which exists in the

various qualities of the grapes. In the south, where the wine is naturally generous, the stalks would only add a disagreeable harshness to a liquor already too strong by its nature. All the grapes, therefore, destined to form wines for the table, are freed from the stalks, while those destined for distillation are fermented with them. But what may appear astonishing is, that in different parts of the same canton in France, we see some agriculturists free their grapes from the stalks, and extol their method, while others in the neighbourhood, equally skilful, reject this practice, and endeavour to support their method by the result of their experience. The one makes wines more delicate, the other wines of a stronger quality; both find partisans of the liquor which they prepare: but this is a matter of taste, which does not contradict the principles we have here laid down.

In general, a fork with three prongs, which the workman turns and agitates in a circular manner in the vat where the grapes are contained, is employed for freeing them from the stalks. By this rapid motion the stalks are detached from the grapes, and, being drawn up to the surface, are removed with the hand.

They may be freed from the stalks also by means of a common sieve formed of osier twigs, distant from each other about half an inch, and having above it a close osier pad or presser, about four inches thick.

But whether the grapes be freed from the stalks or not, it is indispensably necessary to tread them, in order to facilitate the fermentation, and this process is performed as the grapes are collected and brought home from the vineyards. The operation is nearly the same in all the wine countries, and is performed, for the most part, in a square box, open at the top, and about a yard and a half in breadth. The sides consist of wooden bars, with intervals of such a size that the grapes may not pass through

them. This box is placed on the vat, and kept in its position by two beams resting on the edge of the vessel. The grapes are poured into this box as they arrive from the vineyards, and are immediately trod, in a strong and equal manner, by a man, having on his feet large wooden clogs, or strong shoes. While employed in this labour, he rests with his two hands on the edge of the box, stamping with rapidity on the stratum of the grapes, while the expressed juice runs into the vat through the interstices left between the bars. Nothing remains in the box but the pellicle and stalks of the grapes; and when the workman finds that all the juice is expressed, he raises a plank, which forms a part of one of the sides of the box, and pushes the skins and stalks with his foot into the vat. This door slides in two grooves, formed on two perpendicular bars. As soon as the box has been cleaned, a new quantity of grapes are introduced to be trod in the same manner; and this operation is continued till the vat is full, or until the vintage is terminated.

In some countries the grapes are trod in tubs. This method is perhaps better in regard to the effect than the former, but it is slower, and cannot be employed in countries where the vineyards are of great extent.

There are some countries also where the grapes are poured into the vat as they come from the vineyards; and when fermentation begins to take place, the must, which floats on the surface, is carefully removed in order to be conveyed to the casks, where the fermentation is completed. The residuum is then squeezed under a press, to form wine of a higher colour and less flavour.

In general, whatever be the method employed in treading the grapes, what concerns this important operation may be reduced to the two following principles:

Grapes cannot experience spirituous fermentation unless the sugar be extracted by proper pressure, in order

that it may be subjected to the action of those causes which determine the movement of fermentation.

It follows from this fundamental truth, that not only the means proper for treading the grapes ought to be employed, but that the operation will not be complete unless all the grapes are equally pressed; without this the fermentation can never proceed in an uniform manner: the period of the decomposition of the expressed juice would terminate even before the grapes which escaped being trod upon had begun theirs, and there would thus be produced a whole, the elements of which would no longer bear relation to each other. However, on examining the product deposited in the vat after the treading is finished, it will readily appear that the compression has been always unequal and imperfect; and by reflecting a moment on the rude processes employed for treading the grapes, there will be no reason for being astonished at their imperfection of the results.

It appears, then, that to give to this very important part of the labour of the vintage the necessary degree of perfection, it would be necessary to submit to the action of the press all the grapes as they are brought from the vineyard. The juice would be received in a vat, where it might be left to spontaneous fermentation. By this method alone the movement of decomposition would be exercised on the whole mass in an equal manner; the fermentation would be uniform and simultaneous in regard to all the parts; and the signs which announce, accompany, or follow it, would not be disturbed or obscured by particular movements. The must, freed from the stalks and husks, would no doubt produce wine less coloured, more delicate, and more difficult to be preserved; but if the inconveniences of this method exceeded the advantages, it would be easy to prevent them by mixing the expressed refuse with the must.

In consequence of these principles, care ought to be taken to fill the vat in twenty-four hours. In Burgundy the vintage is terminated in four or five days. Too long time would be attended with the disagreeable inconvenience of a successive series of fermentations, which, on that account alone, would be all imperfect; a portion of the mass would be already fermented, while the fermentation would be scarcely begun in another. The wine thence resulting would then be a real mixture of several wines more or less fermented. The intelligent agriculturist, therefore, anxious for the quality of his products, ought to determine the number of the vintagers according to the known capacity of his vat; and when unexpected rain makes him suspend the labour of collecting the grapes, he ought to leave to ferment separately the juice of those already collected and placed in the vat, rather than run the hazard of exposing himself some days after to the danger of interrupting its movements and altering its nature by the addition of fresh and aqueous must.

(To be continued.)

No. 37.

On the Penetration of Balls into uniform resisting Substances. By W. Moore, *Esq.**

To Mr. Tilloch.

Sir,

SHOULD the following paper on the destruction of an enemy's vessel at sea by artillery be thought deserving a place in your excellent Magazine, you are at liberty to make use of it accordingly.

I am, sir,

Your most obedient servant,

W. Moore.

Royal Military Academy,
Woolwich, November 10, 1810.

* Tilloch. v. 36, p. 325.

Lemma I.

If two spheres of different diameters and different specific gravities impinge perpendicularly on two uniform resisting fixed obstacles, and penetrate into them; the forces which retard ***the progress of the spheres will be as the absolute resisting forces or strengths of the fibres of the substances directly, and the diameters and specific gravities of the spheres inversely.***

Let R and r denote the absolute resisting forces of the two substances; F and f the retardive forces; D, d the diameters of the spheres; Q, q their quantities of matter, and N, n their respective specific quantities. Then the whole resistances to the spheres, being by mechanics proportional to the quantities of motion destroyed in a given time, will be as the absolute resisting forces of the substances and quantities of resisting surfaces jointly; or as the resisting forces of the substances and squares of the diameters of the impinging spheres: that is, $\frac{M}{m}=\frac{R}{r}\times\frac{D^2}{d^2}$.

But in general $\frac{M}{m}=\frac{F}{f}\times\frac{Q}{q}$: therefore equating these two values of the whole resisting forces, we obtain $\frac{F}{f}\times\frac{Q}{q}=\frac{R}{r}\times\frac{D^2}{d^2}$, and $\frac{F}{f}=\frac{R}{r}\times\frac{D^2}{d^2}\times\frac{q}{Q}$: and since $\frac{q}{Q}=\frac{d^3}{D^3}\times\frac{n}{N}$, it is $\frac{F}{f}=\frac{R}{r}\times\frac{D^2}{d^2}\times\frac{d^3}{D^3}\times\frac{n}{N}=\frac{R}{r}\times\frac{d}{D}\times\frac{n}{N}$: that is, the forces retarding spheres penetrating uniform resisting substances are as the absolute strengths of the fibres of the substances directly, and the diameters and specific gravities of the spheres inversely.

Lemma II.

The whole spaces or depths to which spheres impinging on different resisting substances penetrate; are as the squares of the initial velocities, the diameters and specific gravities of the spheres directly, and the absolute strengths of the resisting substances inversely; or, $\frac{S}{s} = \frac{V^2}{v^2} \times \frac{D}{d} \times \frac{N}{n} \times \frac{r}{R}$.

For by mechanics we have $\frac{S}{s} = \frac{V^2}{v^2} \times \frac{f}{F}$; and by the preceding lemma $\frac{f}{F} = \frac{r}{R} \times \frac{D}{d} \times \frac{N}{n}$, which substituted in the above it becomes $\frac{S}{s} = \frac{V^2}{v^2} \times \frac{D}{d} \times \frac{N}{n} \times \frac{r}{R}$.

These being premised, I now proceed to resolve the following most important

Problem:

To find a general formula which shall express the quantity of charge for any given piece of ordnance to produce the greatest destruction possible to an enemy's ship at sea; it being supposed of oak substance of given thickness, and at a distance not affecting the initial velocity of the shot.

By Lemma 2, we have, generally, $\frac{V^2}{v^2} = \frac{S}{s} \times \frac{d}{D} \times \frac{n}{N} \times \frac{R}{r}$. Also the charges of powder vary as the squares of the velocity and weight of ball jointly. * Hence, since it has

* This law of variation of the charges does not exactly obtain in practice after a certain charge, on account of the definite lengths of the guns; but it is presumed the deviation from it, if known, would not materially affect our results.

been determined from experiment that a charge of half a pound impelled a shot weighing one pound with a velocity of 1600 feet per second: we shall, considering V the velocity of any ball impinging on the side of the vessel, have for the expression of the charge impelling it through the space $S = \frac{S\,d\,n\,R\,v^2\,w}{2\,D\,s\,N\,r \times 1600^2}$.

Now to apply this in the present instance, it is first necessary that a case be known concerning the penetration of a given shot into oak. Such a case is presented at page 273 of Dr. Hutton's Robins's New Principles of Gunnery. It is there asserted that an 18-pounder cast-iron ball penetrated a block of well-seasoned oak, such as ships of war are generally built with, to the depth of $3\frac{1}{2}$ inches when fired with a velocity of 400 feet per second. Making, therefore, this the standard of comparison for all cases where the object is of oak substance, we shall have for the charge *generally* $\frac{400^2 \times .42}{2 \times 1600^2 \times \frac{7}{24}} \times \frac{S\,n\,R\,w}{D\,N\,r}$; or, because the balls are of the same specific gravity, and the substance the same, or $R = r$, and $N = n$; it will be $\frac{400^2 \times .42}{2 \times 1600^2 \times \frac{7}{24}} \times \frac{S\,w}{D} = .045 \times \frac{S\,w}{D}$; that is the charge varies as the space to be penetrated and weight of ball directly, and diameter of the ball inversely.

But the charge by the question being to produce the greatest effect possible in the destruction of the vessel; S in the above formula must always be put equal to the given thickness of its side *plus the radius of the ball*; since it is well ascertained that, for a shot to produce the most damage to any splintering object, such as oak; it must lose all its motion just as it quits the superior or further surface of it. Hence the charge in question is

$= .045 \times \frac{(\acute{S} + \frac{1}{2} D)\, w}{D}$. $\acute{S}$ being the thickness of the side of the vessel, w the weight of the ball, and D its diameter.

We have supposed, that the resistance opposed to the ball's motion is uniform throughout the entire penetration; which is not strictly true; since that resistance depends partly on the quantity of the surface resisted, which continually varies until the ball has penetrated to the depth of its radius; when it continues uniform till it arrives at the further surface of the object; where the resistance again commences its variation. These deviations from uniformity are about sufficient to set against that of the law of variation of the charges before mentioned; the velocities from them falling somewhat short of the law there prescribed after a certain charge.

Example I.

An enemy's ship is in sight; required the charge for the 42-pounder guns to destroy her as quickly and completely as possible when the ships have approached near to each other: the side of the enemy's vessel (a seventy-four) *being* $1\frac{3}{4}$ *foot thick of oak timber.*

The diameter of a 42-pounder of cast-iron being $= .557$ foot; we get $.045 \times \frac{\acute{S} + \frac{1}{2} D)\, w}{D} = 6.88306$ lbs. or 6 lbs. 14 ozs. for the weight of the charge required.

TABLE

Containing the various charges for the 12-, 18-, 24-, 32-, 36- and 42-pounder guns, for producing the greatest effect in all cases of action: the substance or object being of oak materials, and its thickness together with the radius of the ball from 1 foot to that of 5 feet, regularly increasing by 1 in the inches.

Nature of Ordnance.	Thickness of the Side of the Vessel, plus the Radius of the Ball.			
	12 Inches.	13 Inches.	14 Inches.	15 Inches.
Pounder.	lbs.	lbs.	lbs	lbs.
12	1·439242	1·559178	1·679116	1·799052
18	1·928571	2·089285	2·249999	2·410714
24	2·336650	2·531371	2·726091	2·920813
32	2·830470	3·066343	3·302215	3·538088
36	3·061630	3·316766	3 571901	3·827038
42	3.393180	3·675949	3·958710	4·241475

	16 Inches.	17 Inches.	18 Inches.	19 Inches.
	lbs.	lbs.	lbs.	lbs.
12	1·918987	2·838926	2·158863	2.278800
18	2·571428	2·732142	2·892856	3·053571
24	3·115533	3·310254	3·504975	3·699696
32	3·773960	4·009833	4·245705	4·481578
36	4·082173	4·337310	4·592445	4·847581
42	4·524240	4·806905	5·089770	5·372535

	20 Inches.	21 Inches.	22 Inches.	23 Inches.
	lbs	lbs.	lbs.	lbs
12	2·398737	2·518674	2·638612	2·758547
18	3·214285	3·374999	3·535714	3·696428
24	3·894417	4·089137	4·283859	4·478580
32	4·717350	4·953323	5·189195	5 425068
36	5·102717	5·357853	5·612988	5·868124
42	5·655300	5·938065	6·220830	6·670262

Nature of Ordnance.	Thickness of the Side of the Vessel, plus the Radius of the Ball.			
	24 Inches.	25 Inches.	26 Inches.	27 Inches.
Pounder.	lbs.	lbs.	lbs.	lbs.
12	2.878484	2·998420	3·118358	3·238292
18	3·857142	4·017856	4·178570	4·339284
24	4·673300	4·868021	5·062741	5·257463
32	5·660940	5·896813	6·132685	6·368559
36	6·123260	6·378[illegible]6	6·633531	6·888668
42	6·786360	7·069125	7·351890	7·634655

	28 Inches.	29 Inches.	30 Inches.	31 Inches.
	lbs.	lbs.	lbs.	lbs.
12	3·358228	3·478164	3·598100	3·718036
18	4·521340	4·682054	4·842768	5·003482
24	5·452184	5·646905	5·8416[illegible]6	6·036347
32	6·504432	5·840305	7·076178	7·312051
36	7·143804	7·398940	7·654076	7·909212
42	7·917420	8·200185	8·482950	8·765715

	32 Inches.	33 Inches.	34 Inches.	35 Inches.
	lbs.	lbs.	lbs.	lbs.
12	3·837972	3·957908	4·077844	4·197780
18	5·164196	5·324910	5·485624	5·646338
24	6·231068	6·425789	6·620510	6·815231
32	7·547924	7·783797	8·019670	8·255543
36	8·164348	8·419484	8·674620	8·929756
42	9·048480	9·331245	9·614010	9·896775

Nature of Ordnance.	Thickness of the Side of the Vessel, plus the Radius of the Ball.			
	36 Inches.	37 Inches.	38 Inches.	39 Inches.
Pounder. 12	lbs. 4·317716	lbs. 4·437652	lbs. 4·557588	lbs. 4·677524
18	5.807052	5.967766	6·128480	6·289194
24	7·009952	7·204673	7·399394	7·594115
32	8·491416	8·727289	8·963162	9·199035
36	9·184892	9·440028	9·695164	9·950300
42	10·179540	10·462305	10·745070	11·027835

	40 Inches.	41 Inches.	42 Inches.	43 Inches.
12	lbs. 4·797460	lbs. 4·917396	lbs. 5·037332	lbs. 5·157268
18	6·449908	6·610622	6·771336	6·932050
24	7·788836	7·983557	8·178278	8·372999
32	9·434908	9·670781	9·906654	10·142527
36	10·205436	10·460572	10·715708	10·970844
42	11·310600	11·593365	11·876130	12·158895

	44 Inches.	45 Inches.	46 Inches.	47 Inches.
12	lbs. 5·277204	lbs. 5·397140	lbs. 5·517076	lbs. 5·637012
18	7·092764	7·253478	7·414192	7·574906
24	8·567720	8.762441	8·957162	9·151883
32	10·378400	10·614273	10·850146	11·086019
36	11·225980	11·481116	11·736252	11·991338
42	12·441660	12·724425	13·007190	13·289955

Nature of Ordnance.	Thickness of the Side of the Vessel, plus the Radius of the Ball.			
	48 Inches.	49 Inches	50 Inches.	51 Inches.
Pounder. 12	lbs. 5·756948	lbs. 5·876884	lbs. 5·996820	lbs. 6·116756
18	7·735620	7·896334	8·057048	8·217762
24	9·346604	9·541325	9·736046	9·930767
32	11·321892	11·557765	11·793638	12·029511
36	12·246524	12·501660	12·756796	13·011932
42	13·572720	13·855485	14·138250	14·421015

	52 Inches.	53 Inches.	54 Inches.
12	lbs. 6·236692	lbs. 6·356628	lbs. 6·476564
18	8·378476	8·539190	8·699904
24	10·125488	10·320209	10·514930
32	12·265384	12.501257	12·737130
36	13·267068	13·522204	13·777340
42	14·703780	14·986545	15·269310

	55 Inches.	56 Inches.	57 Inches.
12	lbs. 6·596500	lbs. 6·716436	lbs. 6·836372
18	8·860618	9·021332	9·182046
24	10·709651	10·904372	11·099093
32	12·973003	13·208876	13·444749
36	14·032476	14·287612	14·542748
42	15·552070	15·834840	16·117605

Nature of Ordnance.	Thickness of the Side of the Vessel, plus the Radius of the Ball.		
	58 Inches.	59 Inches.	60 Inches.
Pounder.	lbs.	lbs.	lbs.
12	6·956308	7·076244	7·196180
18	9·342760	9·503474	9·664188
24	11·293814	11·488535	11·683256
32	12·680622	13·916495	14·152368
36	14·797884	15·053028	15·308156
42	16·400370	16·683135	16·965900

In this Table the first column contains the nature of the ordnance, and the numbers in the other columns are their respective charges of gunpowder in pounds, when the thickness of the object to be destroyed is as specified at the top of the columns. If the thickness be given in inches, and parts of inches, take such parts of the difference between the charge for the given number of inches and the next greater; and add them to the charge first found for the given number of inches for the charge required.

The value of the decimal part of each will be had by multiplying it by 16, the number of ounces in a pound, and pointing off in the product from the right hand towards the left, as many places for decimals as are contained in the given decimal, and retaining the number on the left of the point for the ounces, increasing it by $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, or 1, when the first figure of the decimal is 2, 5, 7 or 8 respectively. This hint is merely given for those practitioners who may not be very conversant in decimals.

SCHOLIUM.

This question is not only of the utmost importance and practically useful in naval engagements, but in several instances also of military operations; as the bursting open gates of besieged cities with promptitude and effect, and breaking up all fortifications composed of wooden materials; especially those of a splintering nature, to which the above charges apply most correctly. In the case of a naval action where the object to be penetrated is of oak substance, the ball by having a small motion when it quits the ship's side tears and splinters it excessively, breaking away large pieces before it, which are not so easily supplied in the reparation: whereas on the other hand, if the shot had any considerable velocity when it quitted the side, the effect produced would be merely a hole, which would be stopped instantly by the mechanic employed for that purpose; and indeed in a great measure by the springiness of the wood itself; for I have seen in his majesty's dock-yard at Woolwich, captured vessels having a number of shot-holes in them, almost entirely closed by the wood's own efforts; and that required nothing more than a small wooden peg or a piece of cork to stop them up perfectly: all the damage, therefore, the shot can do under such circumstances of swift celerity is merely killing those men who may chance to stand in the way of their motion.

If any object to be destroyed be so thick that it cannot be completely pierced by any common engine; or if it be of a very brittle nature, such as stone or brick, then that charge is to be used which will give the greatest velocity to the shot to produce the maximum effect. But in many cases of bombardment this charge is by no means to be preferred; for though the effect produced each individu-

al time be greater, yet in any considerable time the whole effect would be less than that from a smaller charge oftener fired, on account of the extreme heat it would give to the engine after a few discharges; and in consequence of which, greater time would be required for cooling the gun and preparing it for further service.

Example II.

Required the charge for a 24-pounder shot to burst open the gates of a city with the greatest ease possible, they being of elm *one foot thick.*

Here the object to be penetrated being elm, the small letters in the general formula $\frac{Sdv^2w}{2Ds\times1600^2}\left(=\frac{(S+\frac{1}{2}D)dv^2w}{2Ds\times1600^2}\right)$: must be made to denote the several numbers of some experiment made in the penetration of this substance. Taking, therefore, the experiment of Dr. Hutton contained in the 5th problem of his elegant Exercises on Forces, we have $d=\frac{1}{6}$ ft. $v=1500$, and $S=\frac{13}{12}$ ft.; also by the question $S=1$ ft. $D=\cdot46$, and $w=24$ lbs. therefore $\frac{(\acute{S}+\frac{1}{2}D)\,dv^2w}{2Ds\times1600^2}=\frac{1\cdot23\times\frac{1}{6}\times1500^2\times24}{2\times\cdot46\times\frac{13}{12}\times1600^2}=\frac{830\cdot25}{191\cdot36}=4\cdot33868$lbs. or 4lbs. $5\frac{1}{2}$ozs. nearly the weight of the charge required in this case.

Retaining the experiment of Dr. Hutton as a standard for all cases where the substance to be penetrated is of elm, we shall have by reduction $\frac{(\acute{S}+\frac{1}{2}D)\,dv^2w}{2Ds\times1600^2}=\cdot0676\times\frac{(\acute{S}+\frac{1}{2}D)w}{D}$: the charge for any piece the diameter of whose shot is D, and weight w; $\acute{S}$ being the thickness of the object as before.

It is not unworthy of remark, that the gates of a besieged place, or any like things, might be effectually broken open by the gun itself, charged only with powder; by placing it close to the gates with its muzzle from them; the momentum of recoil being generally sufficient to force such objects completely.

No. 38.

Of Telegraphic Communication.

[The present state of our national affairs renders the subject of Telegraphic communication an object of considerable interest; and as it comports fully with the extensive range of information which the Emporium contemplates, this subject will be continued in a few of the succeeding numbers. The English word Telegraph, is derived from two Greek words, τηλε, (tele) procul, et γεάφω, (grapho) scribo, implying, to write or correspond at a distance. Ed.]

*Brief Historical Sketch of the Telegraph.**

WE apprehend that some contrivance which, to a certain extent, answered the end of the interesting and important machine, universally known by the appellation of *Telegraph*, and which is of modern application and improvement, was known to the ancients at a much earlier period than many of our readers may have conceived. And when it is considered that the object proposed is, to obtain an intelligible figurative language which may be distinguished at a distance. and by which the obvious delay in the dispatch of orders or information by messenger may be avoided; and that the nature of this work requires us to present all the useful and interesting information in our power relative to each of the topics which come under our review, we presume that a brief historical sketch of that instrument will not be unacceptable to many of our readers.

* Retrospect, v. 5. p. 335. Editorial observations on the subject of Major Le Hardy's Telegraph.

As the name is descriptive of a contrivance by which information is almost instantaneously conveyed to a considerable distance, whenever we find a circumstance of this nature recorded, it is natural to conclude that it was effected by some agent possessing similar qualities. It is generally regarded as a well-authenticated fact, that the burning of Troy was known in Greece a very short time after it happened, and long before it was possible for any person to have arrived there from the scene of conflagration. One of the Greek plays opens with a scene in which a watchman descends from a tower in Greece with the news that Troy was taken. He thus expresses himself: "I have been looking out these ten years to see when that would happen, and this night it is done:" a proof that the ancients possessed some mode of conveying information very quickly to a great distance; but what that mode was, it is not so easy to determine. When the Chinese courtiers travel to distant parts of the empire, signals are made by means of fire from one day's journey to another, in order that preparations may be made for their reception. In most barbarous nations it was customary to give the alarm of war by fires lighted on the tops of hills; and Polybius styles the instruments used by the ancients for communicating intelligence in this manner, *pyrsiæ*, because the signals were made by means of fire. A new method of accomplishing this object was invented by Cleoxenus (some say by Democritus,) and much improved by Polybius. He divided the Greek alphabet into five parts, and expressed the letters on boards in five columns. The order in which these letters were to be taken was signified by torches held up in certain positions, previously agreed upon by the parties.

Neither this last-mentioned method, nor any other known to the ancients, however, appears to have been carried into general use; nor have we any account of any

modern invention for the same purpose previous to the Marquis of Worcester's, contained in his "*Century of Inventions,*" which was published in 1663. In this work he affirms that he had discovered "a method by which, at a window, as far as the eye can discover black from white, a man may hold discourse with his correspondent, without noise made or notice taken; being according to occasion given, or means afforded, *ex re nata,* and no need of provision beforehand; though much better if foreseen, and course taken by mutual consent of parties." This means of correspondence he also asserts to have been rendered so perfect that it could be put in practice "by night as well as by day, though as dark as pitch is black." On the 21st of May 1684, Dr. Hooke, so much celebrated for his mechanical genius, delivered a discourse to the Royal Society on the method of communicating one's mind at a great distance. In this discourse he asserted the possibility of conveying intelligence from one place to another at the distance of 30, 40, 100, 120, &c. miles, "in as short a time almost as a man can write what he would have sent;" and laid down directions for accomplishing it. The whole of this ingenious paper was published in Derham's Collection of Dr. Hooke's "*Experiments and observations,*" and from which it appears that his contrivance was little inferior to several that have been lately proposed for the same purpose. William Amontons, an ingenious French philosopher, about the year 1702, likewise invented a method of conveying information from one place to another by signals; and it is probable without any knowledge of what had been previously advanced on the same subject by the Marquis of Worcester and Dr. Hooke, as his method seems to be much inferior to that pointed out by this last gentleman.

None of these inventions, however, were applied to purposes of utility before the French revolution, when

M. Chappe, towards the end of 1793, invented an instrument of a similar nature, and applied to it the name of *telegraph;* whether or not he knew any thing of the inventions of Dr. Hooke and Amontons it is impossible to say. The first chain of telegraphs formed a communication between the Louvre at Paris, and Lisle, a distance of about thirty-five leagues, near which town the French army then was. The first description of this instrument is said to have been brought from Paris to Frankfort on the Maine by a former member of the parliament of Bourdeaux, who had seen that which was erected at the mountain of Belville, near Paris. Two working models of it were made at Frankfort, and sent by Mr. W. Playfair to the Duke of York: and hence the plan and alphabet of the machine came into England. M. Chappe's contrivance consisted chiefly of an upright post bearing a transverse bar about 10 or 12 feet in length, and 9 inches broad, moveable about a pivot in its centre; to each extremity of this bar an arm of about 3 feet long was attached by a moveable joint: by means of these three the combination of movement was very extensive, simple, and easy to be performed. A number of arbitrary positions were fixed to denote the letters of the alphabet; and these being always made precisely in the same manner by means of the mechanism employed to work the arms, intelligence was conveyed with astonishing accuracy and rapidity.

In consequence of this information various experiments were made in this country,* and a communication by means of a chain of signals was soon established from the Admiralty-office to the sea-coast. The telegraph adopted for this purpose consisted of six octagonal boards, each moveable about an axis, and capable of being placed either vertically or horizontally, so as to be either visible or invisible at the nearest station at plea-

* Great Britain.

sure. These six boards are capable of exhibiting thirty-six changes by the most simple and easy mode of working them; and by these the letters of the alphabet and the numeral cyphers are denoted. This telegraph, however, was by no means considered as being free from objections and inconveniences, and various contrivances for remedying these have been invented since that period. To give an account of all these would greatly exceed our limits; we shall, therefore, content ourselves with mentioning a few of the principal of them. Mr. John Garnet proposed a very simple and ingenious instrument, which consisted merely of a bar or plank, moveable about a centre, round which a circle was described, having the letters of the alphabet and figures depicted round its circumference. An index which corresponded with the bar enabled the operator to set it to any letter or figure he wished to communicate. A wire was fixed across the tube of the telescope used by the observer, which was to be brought to coincide with, or to be parallel to the bar; then the letter or figure to be communicated was denoted by a small index at the eye end of the telescope, which contained a circle similar to that encompassing the centre of motion of the bar. Another ingenious improvement was proposed in the Gentleman's Magazine: it consisted of a semicircle of twelve feet radius: this was to be properly elevated, divided into 24 equal parts, and each of these perforated with a circular opening of six inches in diameter. These apertures beginning from the left, denoted the letters of the alphabet, except K, J, V, X, and Q, which were omitted: the remainder of the holes were reserved for signals. The communications to be made in the day were pointed out by means of an index, and in the night by lamps. None of the preceding telegraphs, however, appear to exceed, either in simplicity, cheapness, or facility of working, that described by J. N. Esq.

in vol. i. of the Repertory of Arts, Old Series. For a nocturnal telegraph it consists of four large patent reflectors, situated in the same plane and parallel to the horizon, but sufficiently elevated above it. Each of these reflectors is susceptible of being elevated or depressed at pleasure by means of winches, and the letters of the alphabet are denoted by the changes. When this telegraph is used in the day, gilt balls, or any other conspicuous objects, are to be used instead of the reflectors. Captain Pasley, of the Royal Engineers, also invented two telegraphs. one of them to be used by day and the other by night:—for a description of these see our fourth volume, page 6.*

Two methods have generally been adopted in communicating telegraphic information: in the one, each signal represents a single letter; in the other, a complete sentence. This last has generally been thought to possess an advantage over the other in point of expedition, but it is only partial in its application; and we have already stated it as our opinion, that the general elements of language only should be transferred, and that every real improvement in the telegraphic art must tend to facilitate the execution of this object.

(To be continued.)

No. 39.

On Signals made by Fire. †

(With a Plate.)

THE subject which Polybius here treats is curious enough in itself; and besides, it bears so near a relation to the facts I am now relating, as to excuse a digression, that will not be of a great length, and which the reader

* These different forms of the Telegraph will be given in subsequent numbers of the Emporium. Ed.

† Rollin's Ancient History, v. 6, p. 321. 9th edit. Dundee.

may pass over if he finds it tedious. I shall repeat it almost literally as I find it in Polybius. Livy, in his account of the particulars above related, and which he copied almost verbatim from Polybius,* mentions the same signals made by fire: but then he only hints at them, because as they were not invented by the Romans, consequently this was a subject which did not relate so immediately to the history he was writing. But this artifice of the signals, which is a part of the art of war, belongs properly to the history of the Greeks, and shows to how great a perfection they had carried all the parts of that noble art, the judicious reflections they had formed in all things relative to it, and the astonishing progress they had made,† in respect to the construction of machines of war, different kinds of armour, and military signals.

As the making signals by fire, says Polybius, though of great use in war, has hitherto not been treated with any accuracy, I believe it will not be proper to pass over them superficially, but to dwell a little upon that head, in order to give my readers a more perfect idea of it.

It is a truth universally acknowledged, that opportunity is of great advantage in all things, but especially in war. Now, among the several things which have been invented to enable men to seize it, nothing can be more conducive to that end than signals made by fire. Whether transactions have happened but a little before, or are then transacting, they may, by this method, be very easily made known, at places distant three or four days journey from where they happened, and sometimes at a

* Philippus, ut ad omnes hostium motus posset occurrere, in Phocidem atque Eubœam, et Peparethum mittit, qui loca alta eligerent, unde editi ignes apparerent: ipse in Tisæo (mons est in altitudinem ingentem cacuminis editi) speculam posuit, ut ignibus procul sublatis, signum, ubi quid molirentur hostes, momento temporis acciperet. Liv. l. xxviii. n. 5.

† Polyb. l. x. p. 614—618.

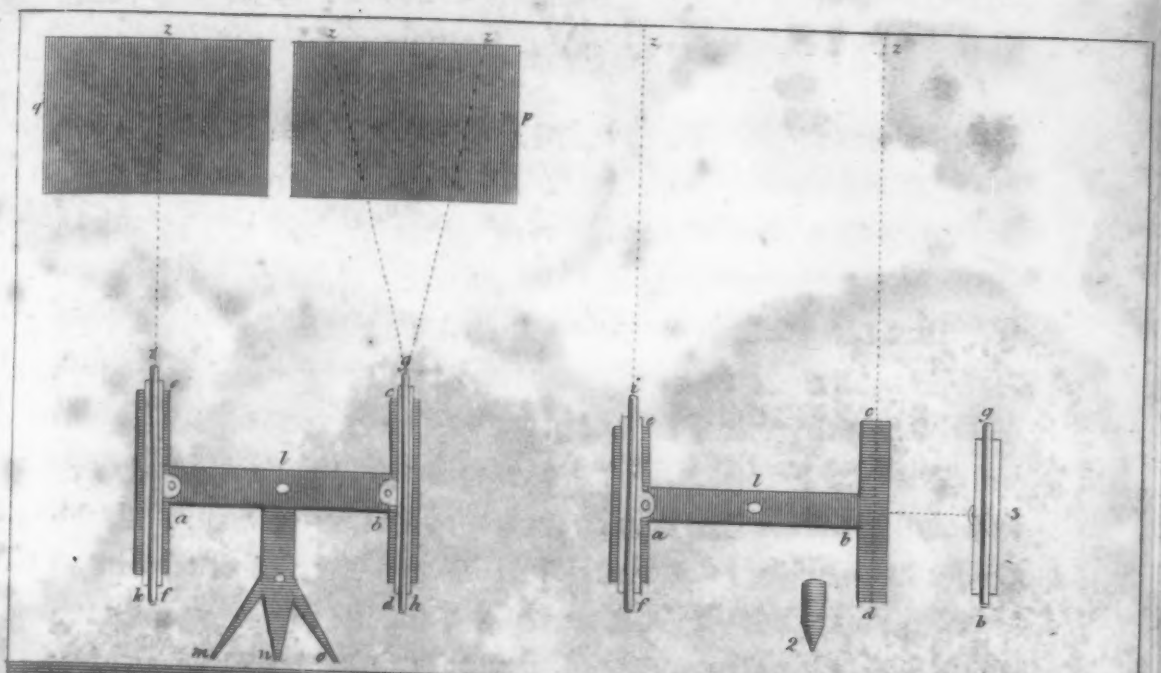
still greater distance; and by this help the necessary aids may be obtained in time.

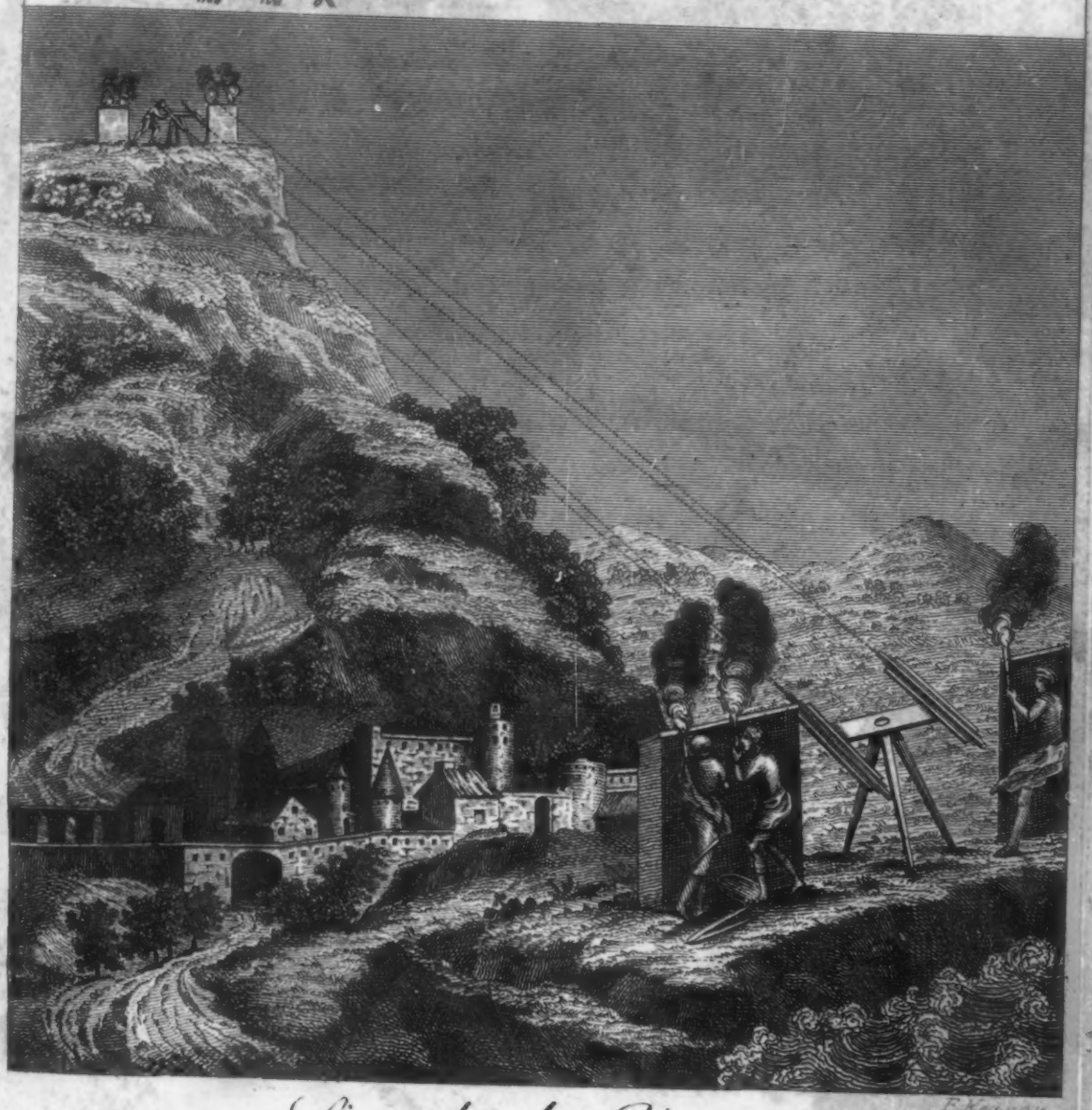
Formerly, this method of giving notice was of very little advantage, because of its too great simplicity; for, in order to the making use of it, it was necessary that certain signals should be agreed upon; and as events are infinitely various, it was impossible to communicate the greatest part of them by this method. As for instance, not to depart from the present history, it was very easy to make known, at a distance, that a fleet was arrived at Oræa, at Peparethos, or at Chalcis, because the parties whom it concerned had foreseen this, and accordingly had agreed upon such signals as might denote it: but an unexpected insurrection, a treason, an horrid murder committed in a city, and such like accidents as happen but too often, and which cannot be foreseen; this kind of events, which require immediate consideration and remedy, cannot be signified by a beacon; for it is not possible to agree upon a signal for such events as it is impossible to foresee.

Æneas,* who wrote a treatise on the duties of a general, endeavoured to complete what was wanting on this occasion; but he was far from succeeding so well as could have been wished, or as he himself had proposed, of which the reader may now judge.

Those, says he, who would give signals to one another, upon affairs of importance, must first prepare two vessels of earth, exactly equal in breadth and depth; and they need be but four feet and an half deep, and a foot

* Æneas was cotemporary with Aristotle. He wrote a treatise on the art of war. Cineas, one of Pyrrhus's counsellors, made an abridgment of it. Pyrrhus also wrote on the same subject. Ælian, Tact. cap. 1. Cicero mentions the two last in one of his epistles. "Summum me ducem literæ tuæ reddiderunt. Plane nesciebam te tam peritum esse rei militaris. Pyrrhi te libros et Cineæ video lectitasse." Lib. ix. Epist. 25. ad Papir. Pœtam.





Signals by Fire.

Emporium of Arts & Sciences. Vol. I Pl. 8.

and an half wide. They then must take pieces of cork, proportioned to the mouth of these vessels, but not quite so wide, that they may be let down with ease to the bottom of these vessels. They next fix in the middle of this cork a stick, which must be of equal size in both these vessels. This stick must be divided exactly and distinctly by spaces of three inches each, in order that such events as generally happen in war may be written on them. For example, in one of these intervals the following words may be written: "A body of horse are marched into the country." On another, "A body of infantry, heavily armed, are arrived hither." On a third, "Infantry lightly armed." On a fourth, "Horse and foot." On another, "Ships." Then, "Provisions:" and so on, till all the events which may probably happen in the war that is carrying on are written down in these intervals.

This being done, each of the two vessels must have a little tube or cock of equal bigness, to let out the water in equal proportion. Then the two vessels must be filled with water; the pieces of cork, with their sticks thrust through them, must be laid upon them, and the cocks must be opened. Now it is plain that as these vessels are equal, the corks will sink, and the sticks descend lower in the vessels, in proportion as they empty themselves. But to be more certain of this exactness, it will be proper to make the experiment first, and to examine whether all things correspond and agree together by an uniform execution on both sides.

When they are well assured of this, the two vessels must be carried to the two places where the signals are to be made and observed; water is poured in, and the corks and sticks are put in the vessels. In proportion, as any of the events which are written on the sticks shall happen, a torch or other light is raised, which must be held aloft till such time as another is raised by the party

to whom it is directed. This first signal is only to give notice that both parties are ready and attentive; then the torch or other light must be taken away, and the cocks set open. When the interval, that is, that part of the stick where the event of which notice is to be given is written, shall be fallen to a level with the vessels, then the man who gives the signal lifts up his torch; and, on the other side, the correspondent signal maker immediately turns the cock of his vessel, and looks at what is writ on that part of the stick which touches the mouth of the vessel; on which occasion, if every thing has been executed exactly and equally on both sides, both will read the same thing.

Although this method differs from that which was practised in early ages, in which men agreed only upon a single signal, which was to denote the event the other party desired to be informed of, and which had been agreed upon, it nevertheless was too vague and indeterminate; for it is impossible to foresee all the accidents that may happen in a war; and though they could be foreseen, there would be no possibility of writing them all on a piece of stick. Besides, when any unexpected accident should happen, how could notice be given of it according to this method? To this I may add, that the inscription on the stick is no ways exact and circumstantial. We are not told how many horse and foot are come; what part of the country they are in; how many ships are arrived; nor the quantity of provisions they have: for before these several particulars could be written on the stick, they must have been foreseen, which was altogether impossible, though most essential; and how can succours be sent, when it is not known how many enemies are to be opposed, nor in what part of the country they are? How must a party either confide in or doubt their own strength? In a word, how will they know

what to do, when they are not told how many ships, or what quantity of provisions are come from the enemy?

The last method was invented by Cleoxenes, which others ascribe to Democlitus; however we have improved it, says Polybius, who continues the sole speaker upon this head. This fixes every circumstance, and enables us to give notice of whatsoever happens. The only thing required is great care and exactness. This method is as follows:

The 24 letters of the alphabet must be taken and divided into five parts; and these must be fixed on a board, from top to bottom, in their natural order in five columns; five letters in each column, the last excepted, which is to have but four.

The alphabet being disposed in this manner, the man who is to make the signal must begin by showing two torches or lights; and these he must hold aloft till the other party has also shown two lights. This first signal is only to show that both sides are ready, after which the lights must be removed.

The affair now is, to make the other party read in this alphabet the advices we want to acquaint them with. The person who gives the signal shall hold up torches to his left, in order to denote to the correspondent party from which of the columns he must take letters, to write them down in proportion as they shall be pointed out to him; so that if it is the first column, he only holds up one torch, if the second, he shows two, and so on, and always to the left. He must do the same to the right hand, to point out to the person who receives the signal, which letter in the column he must observe and write down. This both parties must agree upon between them.

These several things being fixed, and each of them got to his post, the man who gives the signal must have a geometrical instrument with two tubes, in order that he

may know by one of them the right, and by the other the left of him who is to answer. The board must be set up near to this instrument; and to the right and left a solid must be raised ten feet broad, and about the height of a man; in order that the torches which shall be lifted up over it, may spread a strong clear light; and that when they are to be lowered, they may be entirely hid behind them.

All things being thus disposed on each side, I will suppose, for instance, that advice is to be given that "An hundred Cretans, or Kretans, are gone over to the enemy." First, he must make choice of such words as will express what is here said in the fewest letters possible, as "Cretans, or Kretans,* an hundred have deserted;" which expresses the very same idea in much fewer letters.

The first letter is K, which is in the second column. Two torches must therefore be lifted to the left, to inform the person who receives the signal, that he must look into the second column. He then must lift up five torches to the right, to denote that the letter sought for is the fifth of the second column, that is K.

Afterwards, four torches must be held up to the left, to point out the P,† which is in the fourth column; then two to the right, to denote that this letter is the second of the fourth column. The same must be observed with respect to the rest of the letters.

By this method, every event that comes to pass may be denoted in a fixed and determinate manner. The reason why two sets of lights are used, is because every letter must be pointed out twice; the first to denote the column to which it belongs, and the second to show its place in order in the columns pointed out. If the persons employ-

* The words are disposed in this manner in the Greek.

† This is the capital letter R in the Greek tongue.

ed on these occasions observe the rules here laid down, they will give exact notice: but it must be practised a long time before they will be able to be very quick and exact in the operation.

This is what is proposed by Polybius, who, it is well known, was a great soldier and politician, and for this reason his hints ought to be valued. They might be improved and put in practice on a great many occasions. These signals were employed in a mountainous country.

A pamphlet was lent me, printed in 1702, and entitled, "The art of making signals both by sea and land." The pamphlet was dedicated to the king, by the Sieur Marcel, commissioner of the navy at Arles. This author affirms, that he had communicated several times, at the distance of two leagues (in as short a space of time as a man could write down and form exactly the letters contained in the advice he would communicate,) an unexpected piece of news that took up a page in writing.

I cannot say what this new invention was, or what success it met with; but in my opinion such discoveries as these ought not to be neglected. In all ages and nations, men have been very desirous of finding out and employing methods for receiving or communicating speedy advices; and of these, signals by fire are one of the principal.

* In the fabulous times, when the fifty daughters of Danaus murdered all their husbands in one night, Hypermnestra excepted, who spared Lynceus, it is related, that both flying, and each being arrived at a place of safety, they informed one another of it by signals made by fire; and that this circumstance gave rise to the festival of torches established in Argos.

Agamemnon, at his setting out for the Trojan expedition, had promised Clytemnestra, that the very day the

* Pausan. l. ii. p. 130.

city should be taken, he would give notice of the victory by fires kindled for that purpose. He kept his word, as appears from the tragedy of Æschilus, which takes its name from that prince: where the she-sentinel, appointed to watch this signal, declares she had spent many tedious nights in that uncomfortable post.

We also find* by the writings of Julius Cæsar, that he himself used the same method.

Cæsar gives us an account of another method in use amongst the Gauls. Whenever any extraordinary event happened in their country, or they stood in need of immediate succour, they gave notice to one another by repeated shouts, which were catched from place to place; so that the massacre of the Romans in Orleans, at sunrise, was known by eight or nine o'clock in the evening at Auvergne, 40 leagues from the other city.

† We are told of a much shorter method. It is pretended that the king of Persia, when he carried the war into Greece, had posted a kind of sentinels at proper distances, who communicated to one another, by their voices, such news as it was necessary to transmit to a great distance; and that advice could be communicated from Athens to Susa (upwards of 150 leagues) in 48 hours.

It is also related, that a‡ Sidonian proposed to Alexander the Great an infallible method for establishing a speedy and safe communication between all the countries subject to him. He required but five days for giving notice, from so great a distance as between his hereditary kingdom, and his most remote conquest in India: but the king, looking upon this offer as a mere chimera, rejected it with contempt: however, he soon repented it,

* Celeriter, ut ante Cæsar imperaverat, ignibus significatione facta, ex proximis castellis eo concursum est. Cæs. Bell. Gall. l. ii.

† Cœl. Rhodig. l. xviii. c. 8.

‡ Vigenere, in his remarks on the seventh book of Cæsar's wars in Gaul, relates this without citing directly the author.

and very justly; for the experiment might have been made with little trouble to himself.

* Pliny relates another method, which is not altogether improbable. Decimus Brutus defended the city of Modena besieged by Antony, who prevented his sending the least advice to the consuls, by drawing lines round the city, and laying nets in the river. However, Brutus employed pigeons, to whose feet he fastened letters, which arrived in safety wherever he thought proper to send them. Of what use, says † Pliny, were Antony's intrenchments and sentinels to him? Of what service were all the nets he spread, when the new courier took his rout through the air?

Travellers relate, that to carry advices from Alexandria to Aleppo, when ships arrive in that harbour, they make use of pigeons who have young ones at Aleppo. Letters, containing the advices to be communicated, are fastened about the pigeons' necks, or feet; this being done, the pigeons take wing, soar to a great height, and fly to Aleppo, where the letters are taken from them. The same method is used in many other places.

Description of the Instruments employed in Signals made by Fire.

Mr. Chevalier, mathematical professor in the royal college, a fellow-member with me, and my particular friend, has been so good as to delineate, at my request, the figure of the instrument mentioned by Polybius, and to add the following explication of it.—Plate 8.

In this manner I conceive the idea I have of the instrument described by Polybius, for communicating advices at a great distance, by signals made by fire.

* Plin. l. vii. c. 37.

† Quid vallum, et vigil obsidio, atque etiam retia amne prætexta profuere Antonio, per cœlum cunte nuntio?

a b is a beam about four or five feet long, five or six inches broad, and two or three inches thick. At the extremities of it are, well dove-tailed and fixed exactly perpendicular in the middle, two cross pieces of wood, *c d*, *e f*, of equal breadth and thickness with the beam, and three or four feet long. The sides of these cross pieces of timber must be exactly parallel, and their upper superficies very smooth. In the middle of the surface of each of these pieces, a right line must be drawn parallel to their sides; and consequently these lines will be parallel to one another. At an inch and a half, or two inches, distance from these lines, and exactly in the middle of the length of each cross piece, there must be driven in very strongly, and exactly perpendicular, an iron or brass screw, whose upper part, which must be cylindrical, and five or six lines in diameter,* shall project seven or eight lines above the superficies of these cross pieces.

On these pieces must be placed two hollow tubes or cylinders, *g h*, *i k*, through which the observations are made. These tubes must be exactly cylindrical, and formed of some hard, solid metal, in order that they may not shrink or warp. They must be a foot longer than the cross pieces on which they are fixed, and thereby will extend six inches beyond it at each end. These two tubes must be fixed on two plates of the same metal, in the middle of whose length shall be a small convexity, of about an inch round. In the middle of this part must be a hole exactly round, about half an inch in diameter; so that applying the plates on which these tubes are fixed upon the cross pieces of wood *c d*, *e f*, this hole must be exactly filled by the projecting and cylindrical part of the screw which was fixed in it, and in such a manner as

* Twelfth part of an inch.

to prevent its play. The head of the screw may extend some lines beyond the superficies of the plates, and in such a manner as that those tubes may turn, with their plates, about these screws, in order to direct them on the boards or screens *p q*, behind which the signals by fire are made, according to the different distances of the places where the signals shall be given.

The tubes must be blacked within, in order that, when the eye is applied to one of their ends, it may not receive any reflected rays. There must also be placed about the end, on the side of the observer, a perforated ring, the aperture of which must be three or four lines; and place at the other end two threads, the one vertical, and the other horizontal, crossing one another in the axis of the tube.

In the middle of the beam *a b* must be made a round hole, two inches in diameter, in which must be fixed the foot *l m n o*, which supports the whole machine, and round which it turns as on its axis. This machine may be called a rule and sights, though it differs from that which is applied to circumferenters, theodolites, and even geometrical squares, which are used to draw maps, take plans, and surveys, &c. but it has the same uses, which is to direct the sight.

The person who makes the signal, and he who receives it, must have the like instrument; otherwise the man who receives the signal could not distinguish whether the signals made are to the right or left of him who makes them, which is an essential circumstance, according to the method proposed by Polybius.

The two boards or screens *p q*, which are to denote the right and left hand of the man who gives the signals, or to display or hide the fires, according to the circumstance of the observation, ought to be greater or less, and nearer or further distant from one another, according as

the distance between the places where the signals must be given and received is greater or less.

In my description of the preceding machine, all I endeavoured was, to explain the manner how Polybius's idea might be put in execution, in making signals by fire; but I do not pretend to say, that it is of use for giving signals at a considerable distance; for it is certain, that, how large soever this machine be, signals made by two, three, four, and five torches, will not be seen at five, six, or more leagues distance, as he supposes. To make them visible at a greater distance, such torches must not be made use of, as can be lifted up and down with the hand, but large wide spreading fires, of whole loads of straw or wood; and consequently, boards or screens of a prodigious size must be employed to hide or eclipse them.

Telescopes were not known in Polybius's time; they were not discovered or improved till the last century. These instruments might have made the signals in question visible at a much greater distance than bare tubes could have done: but I still doubt, whether they could be employed to the use mentioned by Polybius, at a greater distance than two or three leagues. However, I am of opinion, that a city besieged might communicate advice to any army sent to succour it, or give notice how long time it could hold out a siege, in order to taking proper measures; and that, on the other side, the army sent to its aid might communicate its designs to the city besieged, especially by the assistance of telescopes.

No. 40.

Description of a cheap and efficacious Ventilator for preserving Corn on Ship-board. By Thomas South, *Esq.**

(With a Plate.)

THE importation of grain is a precarious traffic. The produce of distant countries, or even of those near home, when long in collecting, or long detained on ship-board, is subject to heat, soon becomes fetid, and is often so far spoiled and depreciated in its value as to sell for less than the original cost. Hence the merchant, overwhelmed with losses, regrets his patriotism, grows shy of importation, and, unless invited by a certainty of gain, drops the trade, even whilst the nation stands in need of supplies.

The remedy here proposed is a simple, cheap, and, I trust, efficacious method of ventilating grain whilst confined on ship-board; sufficient, I presume, to keep it sweet and marketable after sustaining a tedious voyage.

Description of the Ventilator, with References to the Figures thereof. (See Plate 9, fig. 1 to 7.)

Fig. 1, is a cylindrical air-vessel or forcing-pump, of lead, tin, or other cheap metal; its internal diameter being ten inches, and its length three feet; having a crutch-handled piston to work with, and an iron nosle, viz. a hollow inverted cone, two feet long, to condense the air, and increase its power in its passage downwards. This cylinder should be riveted or screwed, by means of an iron collar or straps, to the deck it passes through, both

* Tilloch, v. 5, p. 393. From the Letters and Papers of the Bath and West-of-England Society for the Encouragement of Agriculture, &c.

above and below, as at *a a*; and should be further secured by some hold-fast near *b*, to keep it steady in working.

Fig. 2, is a bottom of wood, four inches and a half thick, with a projecting rim at its base, for the metal cylinder to rest on, when cemented and screwed to the wood. The centre of this bottom is excavated, for the reception of the crown of the nosle. In the same figure the nosle is represented with its crown like a bowl-dish, to condense the air gradually, without resistance, in its advance to the more contracted base of the inverted cone, i. e. the top or entrance of the nosle. About two-thirds down this nosle may be fixed a male screw, as *c c*, for the purpose hereafter mentioned.

N. B. The forcing-pump should be cased in wood, to protect it from outward bruises, which would prevent the working of the piston, and ruin its effects. The leather round the embolus should be greased when used.

Fig. 3, is a crutch-handle, fastened to the embolus A by its iron legs B, B.—A is a cylinder of wood, cased with leather, so as to fit well, but glide smoothly in the metal cylinder; having an opening as large as its strength will permit, for the free access of atmospheric air. C is a valve, well leathered on its top, and yielding downwards to the pressure of the air when the piston is raised up. D is a cross bar of iron, to confine the valve, so that it may close instantly on the return of the piston downwards.

Fig. 4, is a tin pipe or tube, of less than four inches diameter, and of such length as, when fixed to the base of the cylinder, Fig. 1, shall admit the nosle *d*, Fig. 2, to within half an inch of the valve E, at the bottom of the wooden cylinder F, in Fig. 4; which valve E will then yield to the pressure of air condensed in its passage through the nosle, and deliver it into the pipes below.

This valve must be well leathered on its upper surface, and fastened with an hinge of leather to the cylinder it is meant to close: affixed to its bottom is the spindle G, passing through a spiral spring H, which, being compressed on the descent of the valve, will, by its elasticity, cause it to rise again, close the aperture above, and retain the air delivered beneath it. On connecting this cylinder with the upper end of the nosle, at *e e*, Fig. 2, we must carefully prevent any lapse of air that way, by a bandage of oakum smeared with wax, on which to screw the cylinder, like the joints of a flute, air-tight. I is a bar of iron, having a rising in its centre, wide enough for the spindle to play through, but at the same time sufficiently contracted to prevent the passage of the spiral spring.

Fig. 5, is an assemblage of tin pipes, of any lengths, shaped suitably and conveniently to their situation in the ship, to the form of which, when shut into one another, they must be adapted; observing only, that the neck be straight for a length sufficient to admit the lower end of the cylinder, Fig. 4, as high as the letter F, or higher.

Fig. 6. To the middle pipe, which runs along the bottom, should be fixed a perpendicular one, fully perforated, to convey the air more readily into the centre of the heap; and this may have a conical top, as represented in the plate, perforated with a smaller punch to prevent the air from escaping too hastily. In large cargoes, two or three of these perpendiculars may be necessary; and each should be well secured by an iron bar *g*, screwed down, to prevent their being injured by the shifting of the cargo in stormy weather or a rolling sea. The top of the conical cap of these pipes may reach two-thirds up the cargo.

Fig. 7, is a valve of the same construction as that represented in Fig. 4, but inclosed in a tube of brass, having

a female screw at *f f*, adapted to the male screw *c c*, on the nosle Fig. 2, and may then be inserted into the head of the pipe Fig. 5. This will add to the expense; but, in a large apparatus, is to be preferred, as a more certain security from lapse of air, than the junction of the tube Fig. 4, to the neck *e e* in Fig. 2.

N. B. *e e* is a neck of wood, making a part of the bottom Fig. 2, whereon to secure the tube Fig. 4, when applied to the nosle. The joints of the pipes, when put together for use, should be made air-tight, by means of bees-wax or some stronger cement, till they reach the bottom of the vessel, when there is no further need of this precaution. The horizontal pipes should run by the side of the kelson the whole length of the hold. The tin plates of which K is made, should be punched in holes, like the rose of a watering-pot, in two or three lines only at most, and then formed into a tube, with the rough side outwards. L may have four or five lines of the like perforations. M, and the rest, should gradually increase in their number as they advance towards the middle of the hold, and continue fully perforated to the last pipe, which should be closed at its end to prevent the ingress of the corn. It is the centre of the cargo which most requires ventilating, yet air should pervade the whole. Like the trade-winds, it will direct its course to the part most heated, and, having effected its salutary purpose there, will disperse itself to refresh the mass.

Where the hatches are close-caulked, to prevent the influx of water, vent-holes may be bored in convenient parts of the deck, to be bunged up and opened occasionally, from whence the state of the corn may be known by the effluvia which ascend when the ventilator is working.

The power of the ventilator is determined by the square of its diameter multiplied into the length of the

stroke, and that again by the number of strokes in any given time.

To find the area of a circle, and the solidity of a cylinder raised on that circle, Archimedes gives the following proportion :—

As 1 is to .785398 decimal parts, so is the square of the diameter to the area of the circle.

And, as 1 is to .785398, so is the square of the diameter, multiplied by the height, to the solidity of the cylinder.

The cubical contents, both of the cylinders and tubes, are found in the same manner; their difference consisting not in shape, but solidity, the latter being hollow.

Then, to find the contents of a cylindrical vessel whose internal diameter is ten inches, multiply that into itself, and the square thus obtained, multiplied by .7854, will give the contents of the circle in cubic inches; which, multiplied again by twenty-four inches or lengths of the stroke, being the proportion of the barrel filled with air, gives in cubic inches the amount of each discharge on the descent of the piston. As thus :

	Inches.	
Internal diameter of the pump or tube	10	
	× 10	
	= 100,	or square of the diameter;
which, multiplied by	.7854,	to bring the contents of the square to the contents of the circle.
	78,5400	Contents of the area of the circle.
Which, multiplied by the length of the stroke,	24	inches, produces 1884 cubic inches.
	3141600	
	1570800	
	1884.9600	

which, divided by 231)1884.9600(8.1600 gallons, which is $\frac{16}{100}$ths more than 8 gallons at a stroke; allow these decimals for waste of air

viz. the number of cubic inches in a wine gallon, quotes 8 galls.

369

1386

in each stroke, and 600 strokes to be made in a minute.

Then 8 gallons discharged at a stroke,
multiplied by 60, the number of strokes,

amounts to 480 gallons *per* minute;
which multiplied by 60, the minutes in an hour, produces
28800 gallons in that time;

and that, divided by 252)28800(=114.3 tons. (The number of gallons in a ton, both wine and ship measure) quotes 114 tons in an hour.

Then, suppose the area of the hold of a ship to be = 120 tons, and, when freighted, the interstices between the grains, together with the area between the surface of the corn and the underside of the deck = 5 tons = to the quantity of mephitic air confined; such being the lightest fluid, the major part of it would, soon after the commencement of the operation, be forced, by the atmospheric air, to vent itself at the holes provided for that purpose; and the remainder of the hour being employed in the like ventilation, five tons of fresh air would pass above twenty times repeatedly amidst the grains, to cool, refresh, and sweeten the cargo. A purification thus administered once in eight-and-forty hours, would, I conceive, be amply sufficient to preserve the corn from taint or injury, be the voyage ever so tedious; and unless it should by neglect have overheated and grown together, or settled too close, the labour would be that of a boy only; for the dairy-girl at her churn works harder than he otherwise need to do at this.

My air-vessel is, for the sake of cheapness, confined to the narrow diameter of ten inches; but, as the contents of circles are proportionate to the square of their diameters, by enlarging that, you increase their power accordingly; wherefore, by extending the diameter to fourteen inches, the contents will be nearly doubled; and, by adding ten inches more to the length of the stroke, you almost treble the discharge of No. 1, and obtain a

power capable of ventilating a cargo of 400 tons within the hour. But the air-vessel must be lengthened; the pipes at the same time enlarged; the metal of which the whole is constructed be in substance proportionable; and the labour be that of a man, or perhaps two upon occasion.

A ventilator, on the plan and dimensions here proposed, would come within the compass, I should think, of five or six guineas. One on the larger scale, caused by the increased substance of the metal, and the extra size and length of the pipes, might amount to twenty; which, in either, is under fourpence per quarter on the first cargo; and as they will last many years if well painted, and, when not in use, taken to pieces and put carefully by, I flatter myself it is an experiment well worth trial; particularly if a premium be offered to the ship-owner, who, by means of such machine, imports his corn pure and untainted from a distant land.

Objections made to the supposed Effect of the Ventilator, overruled, it is hoped, by the Considerations which follow them.

First, The holes pierced in the tin tubes which are to lie under the corn, seem capable of issuing (especially if an effort be made upon them) a much larger quantity of air than the forcing-pump will supply in a given time. Consequently, a given quantity of these holes, under a given pressure, will be capable of issuing the whole supply of air, without any assistance from the remainder.

Secondly, If these positions are just, it must happen, that if a cargo of corn be unequally circumstanced in relation to its permeability, the whole of the air discharged by the pump will issue through the *more* permeable parts of it, without affecting, in any degree, the *less* permeable ones.

Thirdly, In cargoes heated in any degree, and in those infected by that worm which fastens grains together by a web, the parts most affected become much more close and densely packed together than the rest, either by the swelling of the heated grains, or by the web and dung of the worms which occupy the intervals between the grains.

If so, the parts of a cargo which require the most ventilation will receive the least; but, in all cases, it seems likely that the air discharged will not regularly permeate the whole of the cargo, but will pass through the parts where the grain lies lightest, and leave untouched those parts where it is most closely packed together.

Answer to the preceding Objections.

Though the holes appear numerous, they must be small, lest the corn gain admission; and many (especially of the uppermost) will be nearly, if not totally, stopped by the pressure of the grains upon them. Besides, the pipes which convey the air towards the centre are not meant to be so fully perforated as those at and beyond it; and all may be still less so, if in practice found necessary. But as the quantity of air delivered by the forcing-pump within five seconds of time is equal to the contents of sixty * feet of four-inch pipe within the first minute, the

* Thus calculated:

	Inches.	
60 feet	4	
× 12 inches	× 4	
Produces 720 inches as a multiplier.	16	the square of the diameter of the pipe.
	× ,7854	
	= 12,5664	or area of the circle.
	× 720	length of the pipe in inches.

Which, divided by 231)9047,8080(=39,1679 gallons and decimal parts, the whole capacity of 60 feet of pipe.

air (notwithstanding the manifold perforations, obstructed as it is in meandering through a mass so nearly compacted as the bottom of the cargo must necessarily be by the pressure of the heap above,) will undoubtedly reach to the end of the pipes, and consequently affect the cargo even there.

Be it further observed, that the flux of air compressed into an half-inch stream, in its passage through the nosle, to enable it to overcome the resistance of the spiral spring H, no sooner passes the valve E, than it expands itself to the compass of the pipe; by which expansion, and extension (at the same time) forwards, its power becomes so weakened, that small egress only will be made, till the pipes are filled with a fluid more dense than atmospheric air, which will then, as is justly noticed, issue where it finds the least obstruction, unless attracted to the spot most heated.

Many circumstances may cause one part of the cargo to be less permeable than the rest; should it prove so, the means readily offer for airing and purifying even this.

Suppose the hatches to be caulked down, and the hold made impervious to water; in such case, the lapse of air, under the obstructions met with in its passage, could by no means keep pace with the influx from the forcing-pump; consequently, if the holes in the deck, designed for its exit, be kept close-stopped till the pumper feels resistance, all the intervals of the cargo, be they ever so

Then, a single discharge of the forcing pump being eight gallons, five such discharges amount to 40 gallons, which is more than equal to the contents of 6 feet of four-inch pipe.

And as on the larger scale of ventilators the pipes need not exceed the same diameter, the power of the air injected, when its egress is stopt, will increase sufficiently to force its way through webs, mats, and other obstructions, though impervious to the atmospheric fluid, unassisted by such mechanic aid.

minute or irregular, must be occupied by fresh air, which, when permitted to escape, will carry off impurities with it. And thus, by stopping and opening such vents repeatedly, no part of the cargo could miss of purification, and this perhaps may be the best mode of administering it.

Prevention is better than a cure.

In a vessel equipped with the apparatus described, the inattention must be great, if the corn be suffered to sustain any injury at all. By an early use of it, perspiration and damps will presently be dried away; heating of course will be prevented; and even the production of the pernicious grub alluded to: for, be the nidus of its eggs ever so productive, their embryos will not vivify, without moisture to sustain them. Wherefore, it should seem that the corn-merchant in future will have little to fear, save the influx of sea-water; and even this (if in small quantities) will, by the frequent use of the ventilator, gradually dry away.

No. 41.

Directions for constructing a cheap Bed, and elastic Frame, for the easy conveyance of sick or wounded Persons. Invented, and most humbly presented to his Royal Highness the Commander in Chief, By PATRICK CRICHTON, ***Lieutenant-colonel of the Second Regiment Royal Edinburgh Volunteers.***

(With a Plate.)

Directions for the Construction of the Elastic Frame.

REFERENCES.

THE lower frame A A (Plate 9, fig. 8,) is made of ash or elm, seven feet long, and five feet four inches broad,

Crichtons elastic frame & bed for conveying sick & wounded persons.

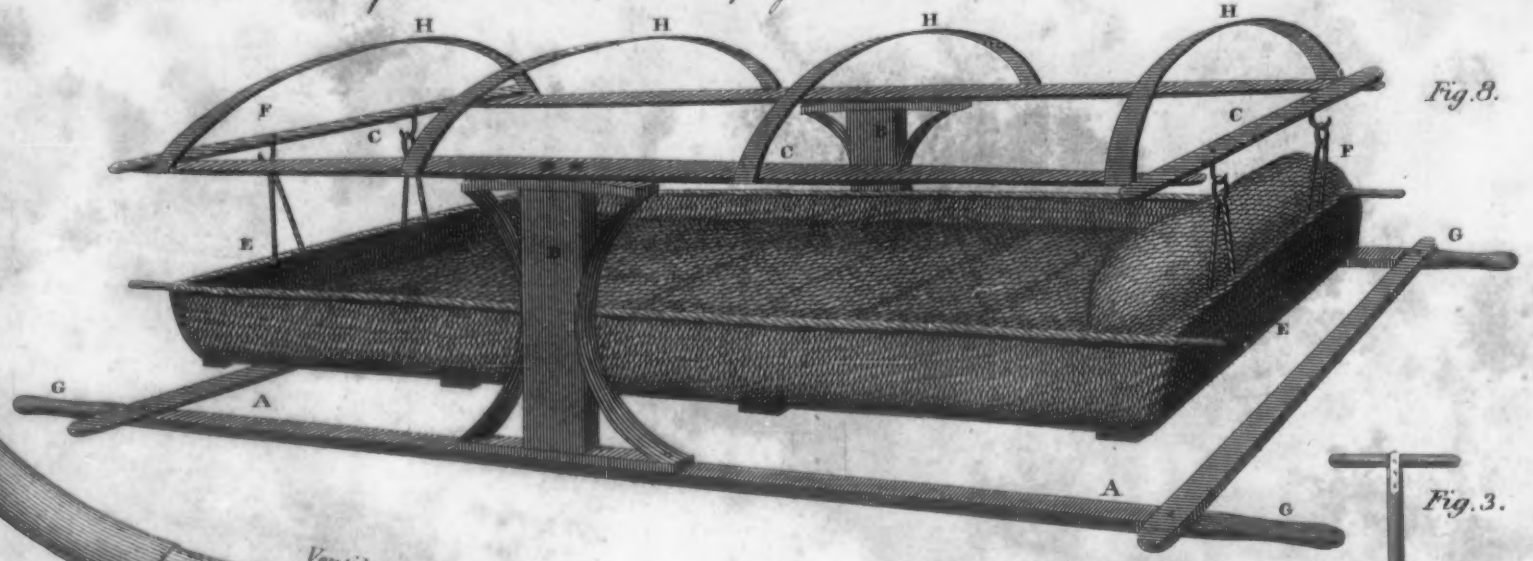


Fig.8.

Fig.5.

Fig.1.

Fig.3.

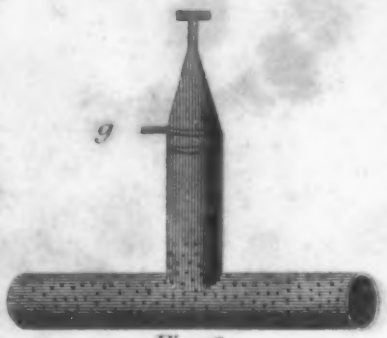
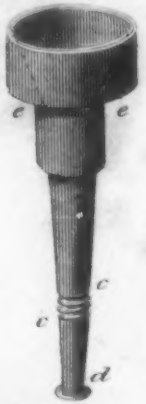


Fig.6.

Fig.4.

Fig.7.

Fig.2.



Emporium of Arts & Sciences Vl.1. Pl.9.

Tiebout Sc.

B B. Two strong wooden pillars, bound on the sides by two circular pieces of iron, for supporting the elastic frame.

C C C. The elastic frame, made of the best ash, supported by the wooden pillars, and semicircular pieces of iron.

E E. The frame or cott, containing a mattress or pelisse, stuffed with straw.—Two or three hammocks may be suspended, and will answer as well as the cott.

F F. Rings and iron hooks, by which the cott, bed, and mattress are supported.

G G G. Four handles projecting from the under frame, one foot three inches long each, by which the whole may be carried by four men.

H H H H. Four semicircular hoops, over which a cover can be thrown, to protect the patient from the weather.

The under frame and pillars should be made of ash or elm, well seasoned.

The elastic, or upper frame, should be made of ash, remarkably clean and well seasoned, thick in the middle where it is supported, and tapering towards the ends.

The total expense of the whole, including the iron-work, should not exceed four pounds ten shillings.

Directions for using the Bed and Frame.

The lower frame may be fastened by ropes to any cart or waggon, of the same size, or larger than itself.

The sick or wounded person should first be placed in the bed. The frame should then be placed over the bed, and the ropes at the head of the bed suspended upon the iron hooks.

Then the ropes at the feet should be hooked up.

The frame, containing one or two sick men, can be easily lifted by the four handles by four men, and carried to any distance to a cart or baggage-waggon.

The lower frame is then fixed to the cart by ropes, and the machine is ready to move.

When the sick are taken from the baggage-cart, the whole frame should be lifted at once, and carried to the hospital.

The bed should then be unhooked, first at the feet and then at the head, and the frame taken away.

Upon large English waggons, two or three of these frames may be conveniently placed.

If the carts of any district are too small for the breadth of the frame, it may be made narrower, so as to adapt it to that conveyance.

When the machine, which is delineated in the plate, was first invented, it was solely intended for the use of the army.

To this purpose it has been successfully applied; and is in common application in several of the garrisons of Great Britain, as affording the easiest means of transporting sick or wounded soldiers, from garrison or quarters, to the hospital.

Since the time of its being adopted by the army, it has likewise been brought into the service of a great many of the public hospitals, not only for the purpose of conveying maimed or bedridden patients from their houses to the wards, but for removing such patients, as were under the necessity of undergoing operations, from the wards to the operation room, and returning them again from the operation room to the wards, without subjecting them to the necessity of being dressed, or even removed from the beds.

Having successfully answered these purposes, it has of late been used, when fixed upon a cart, waggon, or upon the carriage of a postchaise, for removing wounded

persons, or such as were afflicted with disease, and who were unable to support the motion of a chaise or coach, from different parts of the country to the towns where they might enjoy the benefit of medical advice.

In this manner, the use of it, in Scotland, has become of late very general, and, fortunately, very beneficial to those who have travelled in it; all of them concurring, that they were insensible of any unpleasant motion during their respective journeys.

To enumerate the instances of its successful application in this manner would fill a small volume; but a few facts will enable the public to appreciate its value.

A person was brought in it, with a compound fracture in the thigh bone, from the west Highlands to Edinburgh, a distance of 74 miles, in two days.

A gentleman, with an attack of gout both in his hands and feet, was removed from Edinburgh to the north of England, about 140 miles, in three days.

In both these instances, and a great many more, the bed and frame were suspended to the carriage of a post-chaise, and, with a servant sitting in front, travelled post.

Some hundreds of examples can be adduced of the removal of patients by its means, when fixed on a cart or waggon; and in many of these the patients were in a state of the most severe bodily distress and debility.

In all these removals, the patients have borne testimony to their enduring no additional pain or inconvenience from the motion of the machine; all of them, even in the most severe cases, declaring, that they were alike insensible of bodily fatigue, or of the least increase of pain, from the mode of conveyance.

The royal colleges of physicians and surgeons of this place have bestowed upon it the most unlimited approbation, both by letters addressed to the inventor, and in the publications of several of their members.

In consequence of these proofs of its successful effects, and these encomiums from the learned and respectable bodies who are so well enabled to decide regarding its merits, a number of applications have of late been addressed to the inventor, soliciting him to describe and delineate the machine, so as it might be introduced into general use in the various quarters of the kingdom.

To save time in complying with these requests, he adopted the method of printing and circulating these plates, accompanied with a description, which will clearly demonstrate, at how very small an expense, and with how very little mechanical art, the elastic frame can be constructed; for, in fact, there is no village in Britain, in which an ordinary smith and carpenter reside, where it may not be easily made.

Under these circumstances, the inventor feels it a duty he owes to his country, and to those suffering bodily distress, to give it all the publicity in his power; with which view, and with the most ardent wishes for its continuing to prove beneficial, in mitigating the distresses of such as may require its aid, this account is submitted to the public.

Gayfield Place,
17th Sept. 1807.

Indelible Ink.

℞ Lunar Caustic, ʒi: weak solution of Galls, ʒ2. The cloth is to be first wetted with a solution of one ounce of salt of Tartar dissolved in ʒi ſs of water, and must be quite dry before using the ink.

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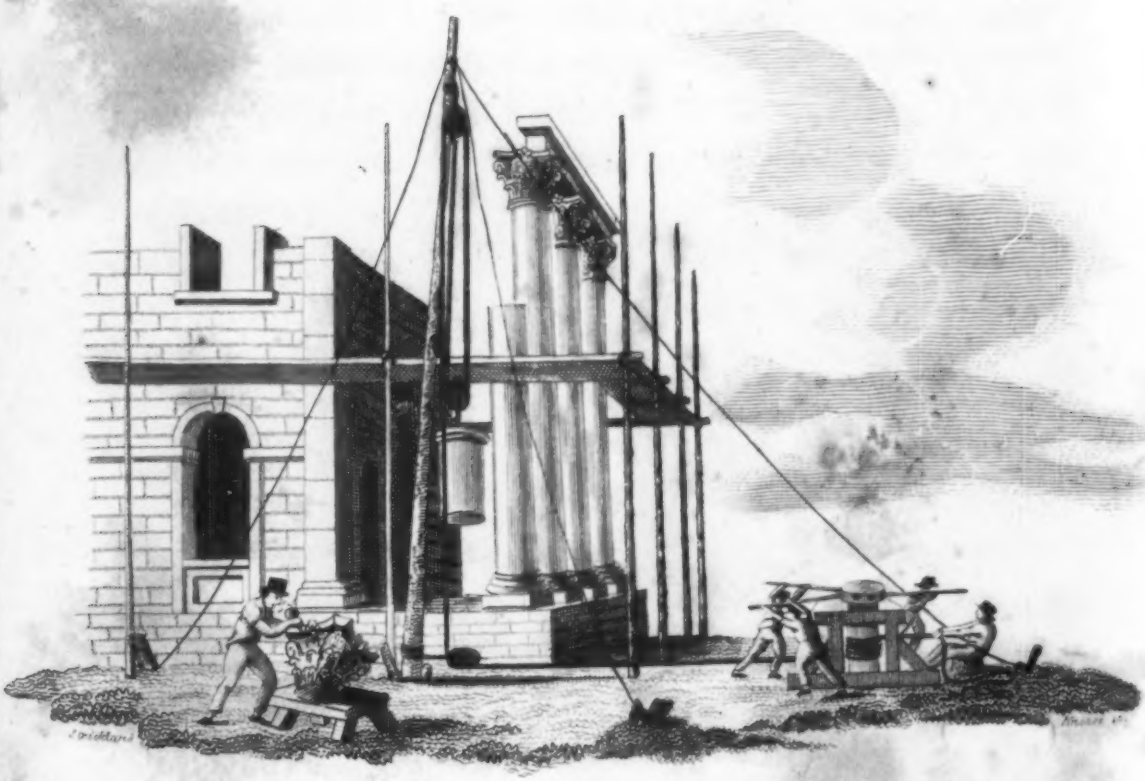
ANOTHER.

Dissolve 4 drachms of Lunar Caustic in 4 oz. of rain or river water. To the clear solution add 60 drops of an infusion of 2 drachms of powdered galls in a gill of boiling water.

The cloth is to be previously wetted with a solution of 1 ounce of pearl ash in 4 oz. of water, and suffered to dry thoroughly.

Philad. Med. Mus. Vol. 1.